SOIL SALINITY STUDIES

in

South Saskatchewan River
Irrigation District No. 1

and

Adjacent Dryland Areas

for

Saskatchewan Water Corporation
Outlook, Saskatchewan

by

J.L. Henry, L.D. Luba, T.J. Hogg, G. Phipps and H. Harder
Saskatchewan Institute of Pedology, University of Saskatchewan
Saskatoon, Sask.

February 1988

Preface

This report describes studies conducted by the Soil Science Department, University of Saskatchewan, within the South Saskatchewan River Irrigation District No. 1. These studies were completed during the 1987 field season and this report written during the winter of 1987-88. The results of the study were then brought to the people of the area through a general public meeting held March 25, 1988, at the Civic Centre in Outlook.

This report is meant to be read in conjunction with "Geology of the Outlook Irrigation Project" Report No. 0117-001 dated November 23, 1987, and authored by E.A. Christiansen of E.A. Christiansen Consulting Ltd. of Saskatoon. That report was provided to authors of this report prior to completion of this report. The possibility of combining the two reports into one volume was rejected because of the physical limitation of information that can be contained within one document.

The reader should obtain the above publication before undertaking a serious study of this report.

A Note on Units

This report uses both metric and English units interchangeably. The fact that both units appear in the same document is not a matter of neglecting to do the conversions. The various options were discussed at length and the use of interchangeable units was adopted as the most desirable course. Unfortunately, we are the generation that must be "bilingual" with respect to units. Drill stems are still 20 feet in length and auger sections are 5 feet in length, and hence samples obtained with this equipment are gathered based on English units. At the same time, piezometer installations are made in metric units and all measurements of water levels are made in metric to the nearest centimeter. Another option would have been to simply duplicate the units and report both English and metric; however, this results in very awkward tables and figures and makes for unpleasant reading. Therefore, we took what we considered to be the common sense approach and produced a "bilingual" document.

Executive Summary

Soil salinity and groundwater problems have developed or increased in severity as a result of irrigation within the South Saskatchewan River Irrigation District No. 1. The purpose of this study was to determine the causes of soil salinity with respect to hydrogeology in SSRID #1. Previous work had related primarily to soil mapping and the geology and groundwater had only been studied on a very broad scale. With the development of canal seepage, salinity and groundwater problems, several individual near surface and groundwater studies had been done on specific parts of the area. However, no study had collated the results of all individual studies or interpreted these studies relative to salinity and groundwater.

This work involved the completion of 15 hydraulic rotary testholes with E-logs and 77 testholes with solid stem auger equipment. In addition, two piezometers were installed with hydraulic rotary equipment and 49 piezometers were completed with the auger. There were a total of10 regional geologic cross-sections completed and and an additional 9 cross-sections drawn within the SSRID #1.

As a result of this work, the SSRID #1 was separated into three distinct areas with specific hydrogeology characteristics and thus specific implications for future management. The reader is referred to Figure 14 which maps the three areas.

Area 1

Area 1 is characterized by generally more than 10 feet of near surface coarse sand and/or fine gravel deposits overlying finer textured lacustrine or till. In this area, with the advent of irrigation, the input of water to the water table became larger than the capability of the system to transmit this water laterally and out of the area through springs, or to transmit it downwards through slow seepage. Thus, the water table rose, creating waterlogging problems and some surface salinity. Typically, in this area, the salt load in the soil profile is low.

IN AREA 1 THERE ARE MANY DIFFERENT POSSIBILITIES TO INCREASE THE GROUNDWATER FLOW OUT OF THE SYSTEM AND HENCE RECLAIM THE SOIL.

Area 2

Area 2 consists of downward fining lacustrine deposits overlying glacial till. In some cases there may be up to a few feet of medium to fine sand above the finer textured lacustrine materials. In Area 2, the main input to the water table system prior to irrigation was through sloughs. In some situations, minor water table accumulations may have been present around sloughs and there probably was some subsoil saline conditions in rings around sloughs. However, under the pre-irrigated condition, the downward movement was sufficient to avoid any serious water table buildup and salinization problems.

IN AREA 2 THE POSSIBILITIES FOR REMOVING EXCESS WATER FROM THE SYSTEM ARE LIMITED. THUS, THE LONG TERM STRATEGY IN AREA 2 MUST BE TO REDUCE THE INPUT OF EXCESS WATER TO THE GROUNDWATER TABLE.

Area 3

Area 3 occurs along the eastern edge of SSRID #1 and continues in a northeast direction from Broderick to Hanley, and in an easterly direction to within a few miles of Kenaston. Area 3 is characterized by the presence of artesian pressure from an extremely complex series of geologic features. These features include intertill aquifers at shallow depths, sands and gravels of the Empress group, the Ardkenneth member of the Bearpaw Formation, and other sandy members within the Bearpaw Formation. Area 3 includes examples where soil salinization is a geologic fact and irrigation should not have taken place in the first instance.

IN ALMOST ALL CASES WITHIN AREA 3, SOIL SALINITY IS A CONDITION WHICH NOT ONLY PREDATED IRRIGATION, IT PREDATED CULTIVATION. IN MOST OF THESE AREAS SOIL SALINITY AND/OR SOLONETZIC SOIL DEDUCTIONS CAN BE FOUND ON MUNICIPAL ASSESSMENT SHEETS AS FAR BACK AS THE 1940'S. POSSIBILITIES FOR RECLAMATION IN AREA 3 ARE LIMITED.

In terms of future management, it is recommended that management in Area 1 should seek to reduce loss of leakage from canals, and concentrate on irrigation management, including return flows, that keep inputs to the groundwater table to a minimum. In Area 2, most of the extra input to the groundwater system is likely through leaky canals and ditches and management emphasis should be on canal lining or replacement with pipe, careful balancing of return flows and perhaps lining of drains. In Area 3, the emphasis should be on planting the affected lands down to a permanent forage cover and discontinuing attempts at annual crop production in addition to eliminating water loss from canals and ditches.

Acknowledgements

Funding for this project was provided by the IBED (Irrigated Based Economic Development) portion of the ERDA (Economic and Regional Development Agreement). The staff and equipment to complete the project were in place because of a much larger soil salinity project, directed at dryland salinity and funded by ERDA.

The authors wish to acknowledge the very significant role of the farmers in the area in allowing this project to be completed. First of all, their support was instrumental in securing the funding. In addition, they willing provided time to explain their observations and access to their land. In some cases, this access resulted in considerable inconvenience in field operations and this was willingly allowed.

Harvey Fjeld of the Saskatchewan Water Corporation gave strong moral support to the project and without his administrative assistance, the project would not have been possible. Many other staff members of the Saskatchewan Water Corporation, Outlook office, provided ideas and access to the historical information in the files. Garth Weitermann, Cass Rogal, Brian Ireland, Lloyd Barteski, Morley Sinclair and Les Bohrson are but a few of the many willing personnel who helped us when needed.

Laurie Tollefson of the P.F.R.A. Farm at Outlook provided constant encouragement for the study and allowed us to locate the field laboratory trailer on the Farm during the investigation. In addition, P.F.R.A. staff from Regina and Saskatoon provided drill logs and cross-sections that had been prepared as part of the geological investigations prior to the Gardiner Dam construction.

Con Hammer of the South Saskatchewan River Irrigation District No. 1 assisted with field traverses, explaining much of the history of irrigation development in the area. As well, members of the District Board provided time and experience when required.

Table of Contents

		Page
1.	**Terms of Reference**	1
2.	**The Study Area**	2
	2.1 Location	2
	2.2 Physiography	2
	2.3 Climate	4
	2.4 Soils and Land Use	4
3.	**Previous and Concurrent Work**	5
	3.1 Geology and Groundwater	5
	3.2 Soils	6
4.	**Methods of Investigation**	13
	4.1 Water Well Survey	13
	4.2 Regional Geology and Rotary Testhole Drilling	15
	4.3 Field Soil Salinity Studies, Auger Testholes and Piezometer Installations	16
	4.4 Laboratory Methods	18
5.	**Results and Discussion**	20
	5.1 Regional Geology	20
	5.2 Soil Salinity and Groundwater Investigations Within SSRID #1	24
	5.2.1 Explanation of cross-sections	24
	5.2.2 Description of specific areas	37
6.	**Conclusions and Management Implications**	47
7.	**Recommendations**	49
	Literature Cited	52

List of Tables

Table		Page
1	Depth, static level and chemical characteristics of water from the wells of W. Bull (NW1-34-27-7-W3) and T.E. Moore (NW13-14-29-8-W3) and testhole 87-115 (NE8-7-27-6-W3)	21
2	Water analyses from flowing well near Broderick marsh (SW3-18-30-6-W3) and the G. Morken farm well (NE9-5-30-6-W3)	23
3	Soil analyses from hand auger samples in a 'true alkali' soil	42

List of Figures

Figure		Page
1	Location map of the study area	3
2	Testhole locations from this study and previous studies	10
3	Form used for the water well survey	14
4	Topography and location of testholes and cross-sections in the Outlook study area	25
5	Cross-section K-K' through the Davison, Larson and Duncan farms	27
6	Cross-section L-L' near the B. Derdall farm	28
7	Cross-section M-M' near the L. Dahl farm	30
8	Cross-section N-N' through the Fuglerud, Larson and Keg farms	31
9	Cross-section O-O' through the R. Pederson farm	33
10	Cross-section P-P' through the B. Niska farm	34
11	Cross-section Q-Q' through the G. Gross and A. Kuffner farms	35
12	Cross-section R-R' through the Broderick Reservoir	38
13	Cross-section S-S' along Highway 15 between the towns of Outlook and Broderick	39
14	Map showing specific areas with different salinization/waterlogging mechanisms	40
15	Schematic diagram of salinization 'rings' around sloughs	44
16	Recommended shallow piezometer installation	50

Appendices

Appendix		Page
A	Summary of salinity and Solonetzic soil deductions from Municipal Assessment data	54
B	Water well maps prepared as part of this study	68
C	Depth, static level and chemical analyses of samples from the water well survey	70
D	Chemical analyses of soil samples from hydraulic rotary drilling	74
E	Auger testhole logs	87
F	Analyses of soil samples from auger testholes	166
G	Specifications of piezometers installed by auger and rotary drill	175
H	Water level measurements from piezometers	179
I	Chemical analyses of water samples from piezometers	190

1. Terms of Reference

This study was conducted by the Saskatchewan Institute of Pedology (SIP) for the Saskatchewan Water Corporation. Funding was provided by the Federal-Provincial ERDA Agreement on Irrigation Based Economic Development (I.B.E.D.).

The objectives of this study were:

(1) to determine the causes of soil salinity with respect to hydrogeology in the South Saskatchewan River Irrigation District No. 1 (SSRID #1) and,

(2) to determine the feasibility of reclamation of saline/waterlogged soils within SSRID #1.

The study was to proceed in two phases. Phase 1 included the completion of the field investigation, preparation of a final report, and a public meeting to be held during the late winter of 1987-88. This report will include only information from the field investigation in Phase 1. Phase 2 is considered a subsequent but separate project.

2. The Study Area

The study area was divided into primary and secondary areas. The primary area was defined by the current boundaries of the SSRID #1 (Figure 1). The secondary area includes adjacent townships that are largely used for dryland farming but includes a portion of the SSEWS canal. Within the secondary study area, only the regional geology was studied.

2.1 Location

The entire study area encompasses a region of about 3000 square kilometers (120 square miles) in west central Saskatchewan. This area includes Townships 27 to 31 and portions of 26 and 32 and Ranges 5 to 9 and portions of 4, West of the Third Meridian (Figure 1). The area west of the South Saskatchewan River was included only for the purpose of completing regional geologic cross sections. The primary study area includes portions of eight townships and is located east of and adjacent to the South Saskatchewan River (Figure 1).

2.2 Physiography

The north half of the study area is largely in the Saskatchewan Rivers Plain while the southwest and southeast corners encompass portions of the Missouri Coteau and the Hawarden Hills Upland, respectively (Acton et al., 1960). The highest point in the study area occurs in the Missouri Coteau Upland at about 2400 feet (732 m) while the lowest point occurs along the South Saskatchewan River at about 1600 feet (488 m). The South Saskatchewan River flows from the south to the north through the study area.

The Saskatchewan Rivers Plain is subdivided into several smaller physiographic units that characterize more detailed features of the study area. Subdivided units include the Moose Woods Sand Hills, Swanson, Stonyridge, Rosetown, Betalock, Hanley, Dundurn, and Outlook Plains (Ellis et al., 1970).

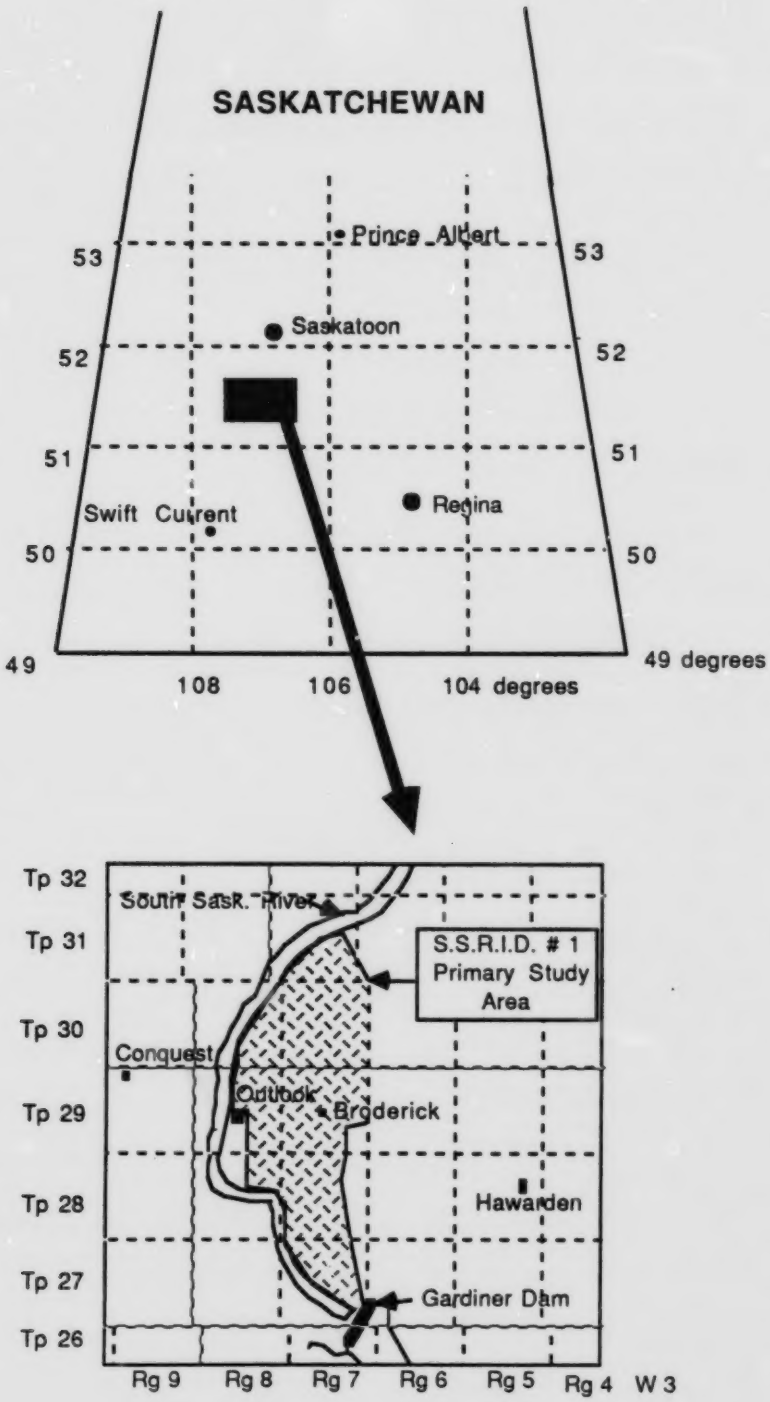


Figure 1. Location map of the study area.

The Outlook Plain is located on the east side of the South Saskatchewan River and is an undulating sandy glacio-fluvial and lacustrine plain with local gently rolling dunes (Ellis et al, 1970). The plain has limited external drainage and slopes from nearly 1900 feet (579 m) on the east and north to below 1800 feet (549 m) at the South Saskatchewan River Valley (Ellis et al, 1970).

Because the prima / study area exists over most of the Outlook Plain only the Outlook Plain will be mentioned. For information about the other physiographic units refer to Ellis et al. (1970).

2.3 Climate

Two meteorological stations are located in the town of Outlook. Mean precipitation and temperature values from the two stations for the years 1951 to 1980 were 31.7 cm (12.5 inches) and 2.75°C, respectively (Environment Canada, 1982).

2.4 Soils and Land Use

Soils in the study area occur in the Dark Brown soil zone (Mitchell et al., 1944). Most soils on the Missouri Coteau and Hawarden Hills Uplands are Chernozemic and belong to the Weyburn soil association while soils along the northern boundary of both upland areas are largely Solonetzic and belong to the Tuxford, Hanley and Rosemae soil associations. Remaining portions of the study area are occupied largely by Chernozemic soils belonging to the Bradwell, Asquith and Elstow soil associations and Regosolic soils belonging to the Dune Sand soil association (Ellis et al., 1970).

In general, most of the well drained nearly level to moderately rolling land areas of medium and finer (heavier) textures are under cultivation and are used for grain production (Ellis et al., 1970). Rough rolling morainic, saline flats, and sand dunes are chiefly utilized for grazing and haying. The better Solonetzic soil areas are used for grain production. In the advent of irrigation, farming practises have changed and a variety of specia' crops are grown in the study area.

3. Previous and Concurrent Work

3.1 Geology and Groundwater

Probably some of the earliest geological and hydrological studies that were conducted in the Outlook area were completed by the Geologic Survey of Canada (Mackay and Maddox, 1936). Mackay and Maddox (1936) presented information on 291 farm wells within the Rural Municipality of Rudy. Most of these wells were relatively shallow (less than 50 feet) and were generally completed in glacial drift. Thirty six wells were completed at depths from 200 to 500 feet and were described as being completed in the Belly River (now referred to as the Judith River Formation). Water from these wells was described as being soft, soda, and frequently salty.

Mackay and Maddox (1936) also provided a map of the R.M. of Rudy which outlined the surficial geology. They also provided approximate boundaries separating areas where the Bearpaw Formation and Judith River Formation formed the bedrock surface. The boundary between the two bedrock formations passed through the village of Broderick in a southwest-northeast direction. Judith (Belly) River Formation was mapped north of that boundary and the Bearpaw Formation was mapped south of that boundary.

The Prairie Farm Rehabilitation Administration (PFRA) completed several feasibility studies prior to the construction of the Gardiner Dam. Numerous testholes were located within one kilometer from the dam site and a large number of them were drilled across the South Saskatchewan River Valley. This information was summarized by Pollock (1962). Pollock also summarized data about the surficial geology in the Elbow-Outlook area by referring to Scott (1960) and data about the Bearpaw Formation at the dam site by referring to Peterson (1954). Information from the many testholes was made available by PFRA, and this data has been included in geologic cross sections contained in this report.

During the preparation of this report additional P.F.R.A. information was discovered. Mortin (1972) had referred to Sask. Agric. C and D Plan No. 901-M15. This was

a map of Tp 28-31, R 3-8, W3 dated April, 1959 and showing 31 testhole logs in which information was obtained from P.F.R.A. Plan No. 2357-DR. 1. At the time of writing (March, 1988), P.F.R.A. was unable to locate Plan No. 2357 but J.A. Robb of P.F.R.A. Geotechnical Division, Saskatoon, did provide 32 testhole logs described as follows: Project: Outlook Special Drilling Program (Olafson); Drilled by: Creelman, Logged by: W.K. Janzen. Testhole 32 was on the Outlook P.F.R.A. pre-development farm and included records of a well constructed by Rankin Drilling.

Sawatsky (1967) prepared a bedrock surface map from seismic information. This map covers many portions of the study area and indicates the location of bedrock highs and lows. Unfortunately, this map did not cover the primary study area, i.e. the South Saskatchewan River Irrigation District No. 1.

Christiansen and Meneley (1971) produced a map of the geology and groundwater resources in the Rosetown map area. This map includes the Outlook study area and shows the presence of a preglacial valley near the town of Outlook. The information available in the mapping of the Rosetown area did not allow the complete and accurate delineation of this valley.

From information provided by geology and groundwater maps completed by Saskatchewan Research Council, a glacial drift thickness map was prepared by Harder and Henry (1986) for areas south of Township 49 . The Drift Thickness map shows the presence of shallow glacial drift (less than 50 feet) in nearly all of the primary study area and particularly in areas north and east of the village of Broderick.

Stewart (1983) produced a potentiometric surface map of the Rosetown map area based on information available from domestic wells. The map was on a 1:250,000 scale with potentiometric lines at 15 m intervals.

Prior to the construction of the Broderick Reservoir, Keith and Associates conducted an auger testhole drilling program in what is now the Reservoir. This report and

drill logs, to depths of about 30 feet, are on file in the Saskatchewan Water Corporation office at Outlook.

In recent years, the development of soil salinity, waterlogging and canal seepage problems has led to a number of specific hydrogeological studies. These studies where conducted by Campbell (1983), Kent (1983), Christiansen (1984) and Straub (1987). The Campbell report consisted of the compilation of existing hydrogeological data for an area west of the M2 canal and about 5 miles (8.1 km) north of Highway 15 between the towns of Outlook and Broderick. This report included an area of about 25 sections from portions of townships 29 and 30, ranges 7 and 8, west of the 3rd Meriden.

The Campbell report documented a rise of the groundwater table in the primary study area (SSRID #1). This rise was related in part, to precipitation and to irrigation. Above average precipitation values were reported between 1965 and 1975 and were believed to contribute to the rise in the groundwater table in both irrigated areas and non-irrigated areas adjacent to the primary study area. Since 1975 the report noted lower precipitation followed by a lowering of the groundwater table in non-irrigated areas. The groundwater table in irrigated areas continued to rise even though precipitation was lower. The report recommended a reduction in the groundwater table by improved drainage, curtailment of irrigation losses , and the use of crops with high water requirements. The report strongly recommended that more detailed studies should be undertaken in each of the problem areas addressing questions such as (a) the nature and distribution of soils and surface materials, (b) water table configurations, (c) groundwater chemistry and (d) the nature and distribution of salts.

The conclusions by Campbell on water table changes over time were based on hundreds of shallow observation wells installed between 1968 and 1980. The wells were installed by the then Conservation and Development Branch of Saskatchewan Agriculture and most of the work was conducted by O.P. Bristol with field installations done by B. Lynch

and M. Sinclair. The observation wells were installed using a one foot diameter Sterling drill. The hole was drilled to about 20 feet and a slotted metal downspout was installed. The hole was then backfilled to ground surface. Detailed soil texture logs for these many testholes are on file in the Saskatchewan Water Corporation office at Outlook. The observation wells were monitored from 1968-1983 and these detailed records are also on file at the Saskatchewan Water Corporation office at Outlook.

Kent (1983) studied specific salinity problems along one specific section (19-30-5-W3) of the SSEWS canal. He concluded that the salinity problems were related to a near surface sand aquifer of bedrock origin. It was believed that improvement of the saline areas could be effected by shallow tile drainage or depressurization of the bedrock sand.

Straub (1987) studied a specific problem section of the M1 canal in Sections 21 and 22-28-7-W3 that was approximately one kilometer in length. The study included dozens of testholes which clearly mapped a near surface sand and gravel deposit as the conductor moving water from the canal to the problem areas. They recommended the improvement of surface drainage, close attention to irrigation and cultural practices and the possibility of pumped well points adjacent to the M1 canal in this problem section.

Christiansen (1984) conducted an investigation related to seepage from canals in both the SSRID #1 area and in the area of the West Main canal. Seventeen hydraulic rotary and four auger testholes were drilled. E-logs were completed on the hydraulic rotary holes. Geologic data from that study provided a starting point for regional investigations in this study.

Christiansen's (1984) study also provided geological information for salinity investigations on the J. Konst farm. Further investigations have been conducted by C. Rogal of the Saskatchewan Water Corporation in Outlook. C. Rogal supervised the drilling of several additional auger holes and the installation of several piezometers. All

auger hole logs provided detailed texture and geologic information. The piezometers have subsequently been monitored on a regular basis and the data is stored by the Saskatchewan Water Corporation office in Outlook.

Subsequent to the Christiansen (1984) study, Barteski (1985) conducted an augerhole drilling program that included 47 augerholes along the M1 canal and four augerholes along the M2 canal. Barteski (1985) estimated that 387 acres were currently affected by salinity/waterlogging problems adjacent to the M1 canal and that a further 128 acres would be affected by 1990. The Barteski (1985) report examined various remedial measures to lessen environmental effects of seepage from the M1 canal.

During the summer of 1987, H. Mathius of the Saskatchewan Research Council (with N.H.R.I.), conducted a groundwater investigation program (on the R. Pederson farm on NE 17-28-7 W3). The objective of his work was to determine the fate of pesticides in groundwater when applied to soils during normal farming practices. Thirteen testholes were drilled and several piezometers were installed. This information is on file in the Saskatchewan Research Council office in Saskatoon.

All of the proceeding investigations were consulted and the information was utilized in these study. The location of testholes from previous investigations and from our study is presented in Figure 2.

3.2 Soils

Earliest soil investigations completed in the study area were conducted by Mitchell et al. (1944). In that investigation the majority of the SSRID #1 was mapped as a mixture of Elstow loam and Asquith very fine sandy loam.

In anticipation of irrigation, detailed soil surveys were conducted in all lacustrine plain areas adjacent to the South Saskatchewan River from Riverhurst to Saskatoon. This work included the SSRID #1. Although never formally published, soil maps on a scale of 1:30,000 were prepared by the Saskatchewan Soil Survey (now SIP). The maps included

general soil maps and soil maps based on a 4 class system for irrigation suitability. In the 4 class system, #1 was rated as excellent, #2 good, #3 fair, and #4 unsuitable for irrigation. These maps are in the files of the Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon.

Information obtained by the South Saskatchewan River soil survey, conducted in the late 1950's and early 1960's, was subsequently published at a scale of 1:125,000 within the Rosetown Map Area (Ellis et al., 1970). Perhaps the most significant newly defined soil association, with respect to the SSRID #1, was the Bradwell soil association. This association primarily included very fine sandy loam soils whose texture was between Asquith and Elstow soil associations. When non-saline, soils belonging to the Bradwell association are some of the most suitable for irrigation.

In addition to providing soil information in much greater detail than previously mapped, this publication was based on the new concept of map units. The map unit concept, as applied by the soil survey, separated specific soil profile types and phases. Most important to irrigation are those map units which delineate saline phases in the landscape.

The Rosetown soil report (Ellis et al., 1970) separates some of the sandier phases within the SSRID #1 as Dune Sand. The Broderick marsh area was mapped using various map units in the Alluvium soil association, that included various saline and solonetzic phases. The lacustrine plain that lies north and east of the village of Broderick was mapped using the Tuxford soil association which is defined as being Solonetzic.

The final source of soil information used in this investigation was provided by the Saskatchewan Assessment Authority for Rural Municipalities. The objective of the Saskatchewan Assessment Authority was to assess the value of each quarter section for taxation purposes. To obtain an assessment, soil conditions are determined and classified. As a result, each quarter section assessment sheet shows a map indicating the soil type(s).

Assessment information was especially useful because it was available on a quarter section basis and because it had been subjected to review by the land owner. In the assessment system the land owner had a right to an appeal if he was not satisfied with the value placed on his quarter section.

In the R.M. of Rudy 284, assessment information was available for the years 1943 and 1971. Salinity and solonetzic deductions that were indicated in the assessments were summarized and used during field investigations for this study. This summary information is provided on a township basis in Appendix A of this report. Original assessment files are with the Saskatchewan Assessment Authority in Regina. Duplicate copies of the 1971 files are on file at the Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon.

4. Methods of Investigation

4.1 Water Well Survey

The water well survey was conducted from Tp 27 to Tp 32 inclusive; east of the South Saskatchewan River to the eastern boundary of R6 W3. In addition, wells were surveyed outside this area if they were on the geologic cross sections of Christiansen (1987).

The primary purpose of the water well survey was to provide information about hydraulic heads and the quality of water from private water wells within the area of study. The water well survey also provided a secondary source of information about regional geologic stratigraphy.

Before water wells were sampled, background information about each water well in the study area was summarized (Figure 3). The information was compiled for all wells as determined from the 1936 Geologic Survey of Canada (MacKay and Maddox, 1936) and from the Saskatchewan Water Corporation records. Water well data from the Saskatchewan Water Corporation is available on microfiche or computer. A computer tape was used which resulted in a significant saving of time.

Access to data from the Geologic Survey of Canada was largely obtained through the Water Supply Papers (Mackay and Maddox, 1936) that were available for each rural municipality. The Water Supply Papers were available from Government Documents in the Main Library at the University of Saskatchewan. In some cases original archival records were consulted. These records are stored by Saskatchewan Archives in the Murray Memorial Building at the University of Saskatchewan. Obtaining information from the original archive records was time consuming and the records were only consulted when inconsistencies were discovered within the Water Supply Papers.

A preliminary water well map was prepared from data supplied by the Water Supply Papers and the Saskatchewan Water Corporation. This map utilized the 1:50,000 topographic map with 25 foot contours. To assist in the reading of the essential map

WATER WELL INVENTORY

Legal Location: QTR ____ LSD ____ SEC ____ TP ____ R ____ W ____

Owner: _____

Address: _____ Surface Elevation: _____

Dept. of Environment Report Available Yes ____ No ____

Archives Report Available Yes ____ No ____

Driller: _____ Date Drilled: _____

Address: _____ Method: _____

E-log: Yes ____ No ____

CASING: Length _____ Bottom _____ Diameter _____

SCREEN: Length _____ Bottom _____ Diameter _____

Decription _____ Slot _____

DEPTH TO WHICH WATER RISES (static water level) _____ (feet)

Source of Depth Information: Report _____ Measured _____ Owner Estimate _____

Well sampled ____ And info verified ____ Abandoned yard ____ Not found ____

Chemical Analysis:

LAB	pH	EC mS/cm	Units	Cations					Anions				SAR	Date Analy.
				Na	Ca	Mg	K	Fe	Cl	SO_4	NO_3-N	HCO_3^-		
SIP			ug/ml											
			meq/l											

Comments: _____

_____

Date Information was Gathered: _____ By whom: _____

Figure 3. Form used for the water well survey.

features photogrammetric procedures were utilized to remove the mercator grid. Certain features on the map such as large sloughs, lakes, rivers and canals were manually highlighted as were the corners of townships. From this modified base map a mylar was prepared onto which the water well information was directly plotted. Upon completion of the water well survey, data concerning new water wells were added. Water well maps prepared for this study are provided in Appendix B.

Field investigations began with a water well survey conducted in April of 1987. During this time water was sampled from farm wells or other water wells in the study area and details about the wells were checked. In some situations the static water level or depth to water was checked at the time of the survey, but for the most part, the information on these parameters was taken from the Saskatchewan Water Corporation and/or Geologic Survey of Canada sources.

All water samples were analyzed according to the methods outlined in Section 4.4. The analyses appear in Appendix C. The water well survey was completed and accessed prior to the next step in the investigation, which was the preparation of preliminary regional geologic cross sections.

4.2 Regional Geology and Rotary Testhole Drilling

All phases of the regional geologic study, testhole drilling and related activities were conducted or supervised by E.A. Christiansen of E.A. Christiansen Consulting Ltd., Saskatoon.

After the water well survey, but prior to the field investigation, preliminary geologic cross sections were constructed from existing information. Existing information included testholes completed from various investigations (see Section 3.1) or testholes or E-logs available from the Farm Test Well Assistance Program of the Saskatchewan Water Corporation. With these preliminary cross sections in hand, field traverses and investigations were conducted and drilling sites were located.

Two hydraulic rotary drilling programs were conducted. The first program was conducted in June of 1987 and consisted of 10 testholes with E-logs and the installation of one piezometer. The drilling program was contracted to Elk Point Drilling Ltd. of North Battleford, Saskatchewan. The drillers in the program were J. Solininko and G. Toplika.

The second drilling program was conducted in August of 1987. The drilling program was contracted to Hayter Drilling Ltd. of Watrous, Saskatchewan and the drillers were C. Higgins and N. Street. Five testholes with E-logs were completed and one piezometer was installed.

Soil samples were obtained at 2.5 foot intervals for the first 20 feet of hole drilled and at 5 foot intervals for the remainder of the testhole. These samples were obtained according to the method described by Hogg and Henry (1985). Chemical analyses of these samples are in Appendix D.

Fresh water having an electrical conductivity (EC) from 300 to 400 µS/cm at 25°C was used for all testholes, and all testholes were E-logged immediately upon completion of drilling.

4.3 Field Soil Salinity Studies--Auger Testholes and Piezometer Installations

The first step in the field investigation was field traverses by J.L. Henry in the company of G. Weitermann and C. Rogal from the Saskatchewan Water Corporation and C. Hammer of the S.S.R.I.D. District Board staff. Individual farmers were consulted and their explanation of observations and cropping history was invaluable in this phase of the study. Photomap mosaics of each township were utilized in early stages of the investigation. In the later stage these photo mosaics were utilized, but with the addition of superimposed 5 foot contour lines. In addition, air photos dating back to 1944 were obtained for selected quarter sections in the study area.

The Geonics EM-38 non-contacting terrain conductivity meter (EM38) was extensively used for individual field traverses (Cameron et al., 1981) and aided in the selection of testhole locations.

A B-47 mobile drill was used for drilling augerholes and earth materials were identified by L.D. Luba of the Soil Science Department, University of Saskatchewan. The augerhole logs are in Appendix E. This drill was equipped with 6-inch diameter solid stem augers in 5 foot lengths. For practical purposes, the maximum depth of penetration drill was 73 feet. During the augering program drill cuttings were laid out on canvas strips that were marked in one foot increments. The auger was tripped out at regular intervals and samples were taken in five foot increments. At least one sample was taken from each geologic stratum. These samples were analyzed according to the methods given in Section 4.4. The analyses are reported in Appendix F.

In most cases piezometers were installed in augerholes drilled specifically for that purpose. The piezometer was prepared by glueing a 15 inch length of 10-slot 2-inch diameter PVC screen onto 2-inch schedule 40 PVC pipe. Upon fitting the piezometer into the augerhole the screen was packed with 12-20 frac sand and sealed with barite. The detailed piezometer specifications are given in Appendix G.

Static water levels were recorded over time. The piezometers were surveyed to a common internal datum. Water level measurements are given in Appendix H. Prior to sampling the water from each piezometer, at least one water volume was removed from the piezometer using an air-lift pumping system. A bailer was used to take a water sample after the piezometer was pumped. Water analysis was by methods outlined in Section 4.4. Chemical analyses of water samples from piezometers are in Appendix I.

Slug tests were completed on selected piezometers so that the hydraulic conductivity of earth materials near the piezometer tip could be determined. The slug test data has not been summarized and is not included in this report.

4.4 Laboratory Methods

Samples collected during augering and hydraulic rotary drilling operations were stored in the field-moist condition and the moist samples were used for analysis. The samples were mixed with distilled water to give a 1:1 soil:water ratio (dry basis) and stirred for approximately 1 hour (Rhoades, 1982). The pH and EC of the 1:1 suspensions were measured using a standard pH electrode and an immersion-type conductivity cell, respectively. The EC of 1:1 soil:water suspensions has previously shown to accurately assess the salinity of Saskatchewan soils (Hogg and Henry, 1984) and to give a realistic indication of the salinity profile of geologic sediments from hydraulic rotary drill cuttings (Hogg and Henry, 1985). EC readings of the 1:1 suspensions were recorded in dS/m at 25°C.

Extracts were obtained by filtering the 1:1 suspensions. Selective ion electrodes were used to measure ion concentrations of the extracts. The ions that were measured were Na^+, $Ca^{2+} + Mg^{2+}$ (divalent cation), K^+ and Cl^-. Extracts with a high ionic strength, as estimated from the EC of the extracts (Griffin and Jurniak, 1973), were diluted 10 times prior to analysis of Na^+, K^+ and Cl^-. Divalent electrode analysis ($Ca^{2+} + Mg^{2+}$) was determined only on the diluted extracts. Since the divalent electrode did not distinguish between Ca^{2+} and Mg^{2+} the mean milliequivalent weight of Ca^{2+} and Mg^{2+} was used when calculating concentrations.

EC of the extracts was measured using a flow and pipette-type cell connected to a conductivity meter. The conductivity meter was capable of automatically correcting the reading to a reference temperature of 25°C.

EC of the extracts were used to calculate the Total Salt Concentration from the relationship between Total Cation Concentration and EC of soil extracts (Richards, 1954):

$$\text{Total Salt (meq/l)} = 10 \text{ E.C. (dS/m)}$$

The calculation of Total Salt in this manner provided an estimate of the Total Cation Concentration of the extracts and thus provided a check on the Total Cation Concentration measured with the electrodes.

Sodium adsorption ratios (SAR) were calculated for all extracts using the following formula (Richards, 1954):

$$SAR = \frac{Na^{+}\ (meq/l)}{\sqrt{\frac{(Ca^{2+} + Mg^{2+})\ (meq/l)}{2}}}$$

Water samples that were collected from piezometers and farm wells were analyzed in the same manner as the soil extracts. In addition HCO_3^- and NO_3^--N concentrations were measured on the water samples. HCO_3^- concentrations were measured by titration with standard acid to a color indicator end-point (Richards, 1954) and NO_3^--N concentrations were measured with a nitrate selective ion electrode. To remove any interfering ions and prevent microbial growth the water samples were mixed with a NO_3^- buffer solution (1:1 water:buffer) prior to NO_3^--N analysis (Milham et al., 1970). The water samples were not diluted prior to analysis since the buffer eliminated the problem with ionic strength.

5. Results and Discussion

5.1 Regional Geology

The regional geology was conducted by E.A. Christiansen and a separate bound report is available with this information (Christiansen, 1987). The discussion of regional geology included in this report will make reference to drawings and cross-sections that occur in the Christiansen report. It has not been reproduced within this report because of the physical limitation of information within one document. The drawing and cross-section numbers utilized in Section 5.1 are those of Christiansen (1987).

The major geologic feature discovered in this project, and of significance to soil salinity and groundwater movement interpretations, is the existence of the Outlook Valley; cross-section G-G'--Drawing No. 0117-001-09 (Christiansen, 1987).

One concern expressed by farmers with soil salinity problems in SSRID #1 was the possibility of direct movement of water from Diefenbaker Lake causing underground pressure and salinization. Such movement would require a highly permeable aquifer directly connected to the Reservoir and would require blockage of flow back to the South Saskatchewan River Valley downstream. If this occurred, changes in static level would be noted in wells completed in the aquifer. If such an aquifer exists it would have to be the Outlook Valley discovered as part of these investigations. We have traced this Valley from Outlook in a southeasterly direction. It passes east of Cutbank and east of Gardiner Dam (Drawing No. 0117-001-01). Reference to cross-section G-G' shows this Valley and reference points within it. Pollock (1962) shows information which suggests a possible branch of the buried valley west of Gardiner Dam. Testhole 87-115 (Christiansen, 1987, Index No. 326) was a piezometer installed by us as part of this program on the property of Mr. G. Stone east of Gardiner Dam. This shows a static water level about equal to the F.S.L. of the Diefenbaker Lake. The next documented occurrence of the Outlook Valley is Index No. 167 (Christiansen, 1987). The next reference points are the water wells of Mr. W. Bull

(NW1-34-27-7-W3, Index No. 324) and the water well of Mr. T.E. Moore (NW13-14-29-8-W3, Index No. 65). It is interesting to note the chemistry data on water from these two wells (Table 1). They are characterized by similar water of low E.C. and SAR. The extremely low head of the Moore well (about 1620 feet above sea level) suggests that the aquifer is draining freely into the South Saskatchewan River alluvium and does not build up any head and could not be associated with soil salinity problems in the Outlook area. The fact that the water at testhole 87-115 (Table 1) has an E.C. about double that of the Bull and Moore wells suggests that there is little flow from 87-115 to the area of the farm wells.

Table 1. Depth, static level and chemical characteristics of water from the wells of W. Bull (NW1-34-27-7-W3) and T.E. Moore (NW13-14-29-8-W3) and testhole 87-115 (NE8-7-27-6-W3).

Name	Well depth	Static* level	E.C. µS/cm @ 25°C	S.A.R.	Cl^-	NO_3^-N
	feet				ppm	
W. Bull	160	25	800	0.7	7	<1
T.E. Moore	170	130	1050	2.6	6	<1
Testhole 87-115	272	84	2060	1.5	5	1

*Below ground surface

Another geologic feature of note and of interest relative to soil salinity is the existence of ice thrusting which occurs in the general area south and east of Broderick Reservoir. The existence of this phenomena is documented by aerial photographs and the ridge and swale pattern of topography in the region. A large scale Landsat photograph on file in Saskatchewan Water Corporation Offices at Outlook, and covering the area from

Saskatoon to Gardiner Dam, shows the existence of this phenomena in particularly clear fashion.

Field evidence of the existence of ice thrusting occurs just south of the western embankment of Broderick Reservoir. In the embankment exposed to allow the placement of the large grain annex (owner John Case), a "boulder" of shale belonging to the Bearpaw Formation is visible. As well, in the eastern embankment of the M1 canal at that same point, very large "boulders" of gravel can be observed. There is considerable field evidence to suggest that the last glaciation actually carried out the excavation that formed the trough within which the Broderick Reservoir was constructed.

The other geologic feature of particular significance to soil salinity and solonetzic soil problems is the existence of very shallow glacial drift deposits overlying bedrock of the Bearpaw Formation. This condition occurs north and east of Broderick on the eastern boundaries of SSRID #1. The Bearpaw Formation consists primarily of very slowly permeable clay and silt deposits, but does contain significant sand members (e.g. Ardkenneth member) and in some locations contains significant sand lenses within the overall silt and clay matrix.

Cross-section B-B' illustrates an example where the Ardkenneth Formation is present (Christiansen, 1987). Hole No. 338 (projected into B-B') is at the southern end of Broderick marsh. On information from local farmers this hole was drilled as part of an exploration program prior to 1940 and during the late 1930's and early 1940's was used as a local water supply. This well is still flowing and has created an organic soil environment surrounding the well. No information is available on the depth of the well, but we sampled and analyzed the water. The water chemistry is quite similar to that of the G. Morken well which is Index No. 268 on cross-section I-I' (Table 2).

Table 2. Water analysis from flowing well near Broderick marsh (SW3-18-30-6-W3) and G. Morken farm well (NE9-5-30-6-W3).

Name	Approx. surface elevation	Well depth	Static* level	E.C. µS/cm @ 25°C	S.A.R.	Cl^-	NO_3-N
	feet					ppm	
Broderick marsh	1745	unknown	flowing	3700	17	340	2
G. Morken	1755	195	flowing	3560	19	485	<1

*Below ground surface

Thus, most of the Solonetz, subsoil salinity and surface salinity problems in the vicinity of the junction of Highways #15 and #219 are related to the high water table maintained by the constant propensity for upward movement from the Ardkenneth Formation and other aquifers and sandy zones within the Bearpaw Formation. These aquifers are at too high an elevation to have access to drainage through the regional subsurface drainage system within the Outlook-Tyner Valley system, and this results in the pressure and artesian conditions.

South of Broderick there are no examples of well developed aquifers in the Bearpaw Formation, but there are sandy members and upward heads are present throughout the area. This is documented at Index No. 98 on cross-section D-D' (Christiansen, 1987). The presence of the sandy layer was documented in the 1984 canal drilling program (Christiansen, 1984) and we went to that exact location and installed a piezometer in a sandy layer at the depth shown by the E-log on the earlier testhole. The water in this piezometer has an E.C. of 5980 µS/cm @ 25°C and an SAR of 21; typical of the water chemistry in bedrock formations.

Cross-section D-D' (Christiansen, 1987) from Index No. 98 to Index No. 320 shows the typical condition in the eastern part of the project. This part of the cross-section

documents the shallow nature of glacial drift deposits throughout this area; east of the Outlook Valley and west of the Hawarden upland moraine.

The shallow nature of glacial drift deposits is also documented in Index Nos. 221 to 227 in cross-section H-H'. An upward gradient from the shale is documented by a piezometer nest at Index No. 223 (see Section 5.2).

The other geologic feature shown on cross-section H-H' is the nature of relatively thick sand deposits with drainage to the river in the central and western portions of Tp 31 R7-W3. Index Nos. 239 to 315 illustrate this with three farm wells all showing very low mineralization and a very low SAR. This is the area generally referred to by the local residents as "sand point country". In this area where the slope of the till or heavy textured lacustrine material is towards the South Saskatchewan River, drainage will occur naturally and soil salinization problems would not be anticipated. The exception to this would be on the river bank where natural springs cannot drain the extra input due to irrigation. In that situation soil salinization/waterlogging would occur on riverbank locations. This has already occurred on 21-31-7-W3.

The scale of the cross-section H-H' can lead to some oversimplification of the "sand point" model. In parts of this area, where the sand deposits are relatively thick, local relief on the glacial till surface may result in imperfect or totally impeded drainage away from the area. In such situations, water table problems are inevitable under irrigation.

5.2 Soil Salinity and Groundwater Investigations Within SSRID #1

5.2.1 Explanation of cross-sections

The location of the cross-sections and testhole numbers are plotted on Figure 4. These cross-sections were prepared and drawn by L.D. Luba from augerholes completed as a part of this study, and all other testhole sources available in Saskatchewan Water Corporation files in Outlook, Saskatchewan Research Council files in Saskatoon, and the

PFRA files in Regina. The names utilized on the cross-sections are the landowners as published in the 1987 edition of the land tenure map of SSRID #1.

K-K':(Figure 5) From testhole OK14 to testhole OK110, the stratigraphy is characterized by near surface sand and gravel deposits overlying either glacial till or much finer textured lacustrine material. In this situation groundwater flow will be determined by the configuration of the glacial till or fine-textured lacustrine material. From testholes SWC39 to OK14, the general groundwater flow pattern will be towards the South Saskatchewan River. Unfortunately, the coarse material does not continue directly to the river banks. If this were the case, springs would be the result, and the area would be naturally drained. This particular portion involves a situation with many possibilities for drainage because there is ample permeability to promote drainage.

From testhole OK1 to SA594 there is some near surface fine sand which would promote lateral flow. In this region the piezometer nest within the till (at OK1) shows that there is little or no downward gradient and hence the downward flux will be essentially zero. This means that any additional water entering the water table must be dealt with locally because there is little transport out of the system. From testholes OK46 to SA44 represents a region with very thin lacustrine deposits overlying glacial till. We would interpret this area to have a very minimal, if any, downward gradient.

From OK47 and eastward there is extremely shallow lacustrine cover overlying shallow glacial till deposits with shale of the Bearpaw Formation at depths of approximately 20-30 feet. The nest at OK47 shows a slight upward gradient from the highly disturbed near surface Bearpaw shale.

L-L': (Figure 6) This cross-section shows a special situation that exists adjacent to a major sand ridge that dissects Township 30, Range 7 in a northwest to southeast direction. This sand ridge is not visible on a contour map with 25 foot contour intervals, but

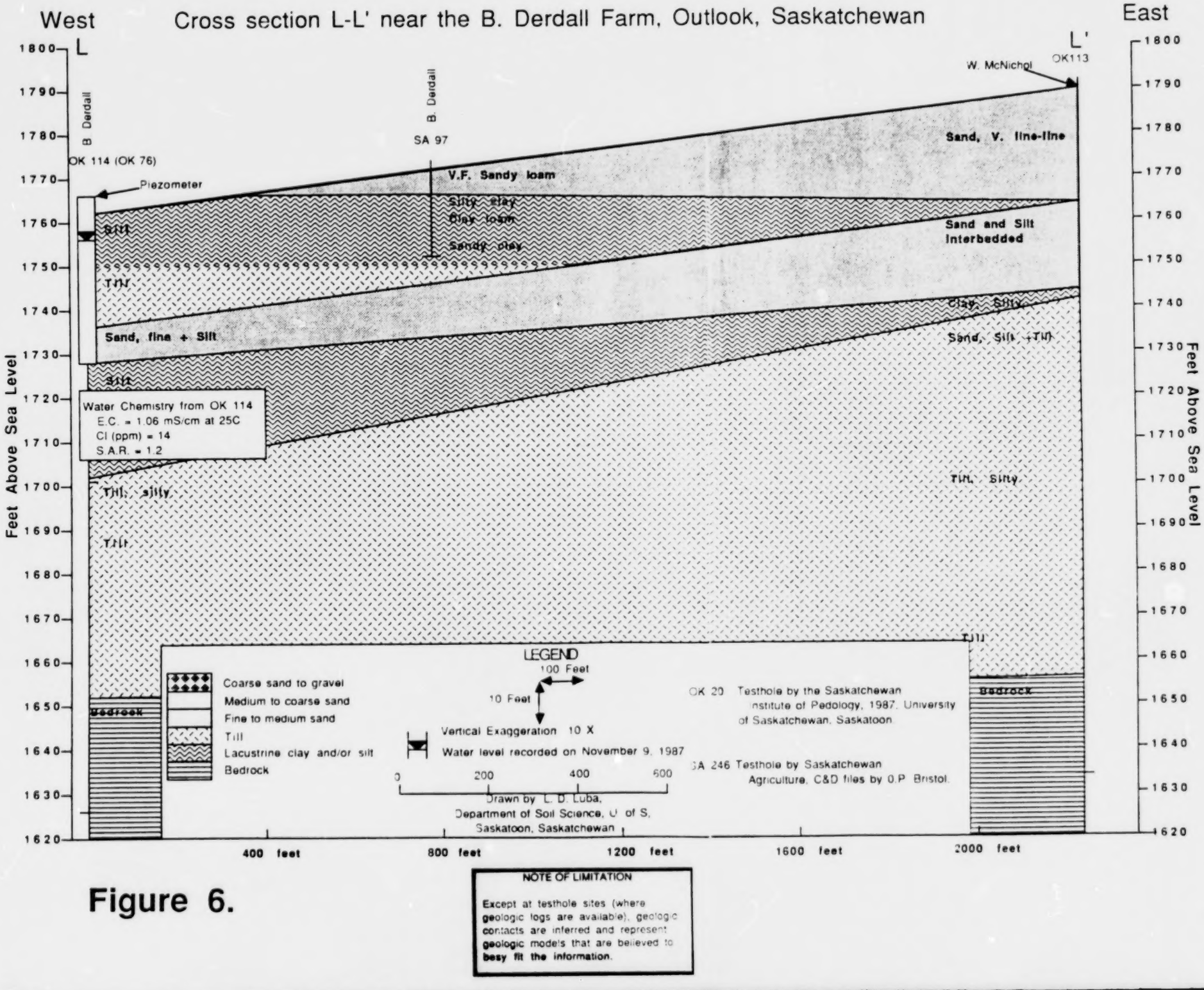


Figure 6.

NOTE OF LIMITATION

Except at testhole sites (where geologic logs are available), geologic contacts are inferred and represent geologic models that are believed to best fit the information.

it is quite easily discernible on the photo maps on which 5 foot contour lines have been superimposed.

Testhole OK76 and piezometer installation OK114 show the presence of a fine sand and silt strata that is connected to the sand ridge. The static level in the piezometer is approximately 3 feet below ground and above the water table and represents a local artesian situation. This is in an area where soil salinity has been present for decades and is not directly related to irrigation. However, increased irrigation development on the sand ridge would be expected to increase soil salinity problems on the edges of the sand ridge.

M-M': (Figure 7) This cross-section shows a well-drained situation typical of that encountered in "sand-point country". A return flow drain near testhole OK40 services two quarter section pivots. The return flow disappears into the surface sand within approximately 0.5 miles of the release point. This, and other inputs to groundwater, drain towards natural springs near testholes OK41 and OK35. The natural springs are unable to remove the extra water and soil salinity/waterlogging problems have developed. Near testhole OK35 a recent spring sapping event has resulted in a large gully in a farm field.

N-N': (Figure 8) From testholes SSSL11 to SSSL7 represents a region with near surface coarse sand to gravel and fine to medium sand deposits. Much of this portion is an area of high relief with only one irrigation pivot and one small acreage market garden operating at present. Further development of irrigation in this area represents a significant risk of salinity problems unless drainage to the river valley is provided. From OK22 to OK28 represents a region with downward fining lacustrine deposits overlying slowly permeable glacial till. The piezometer nest at OK29 documents the fact that there is very little, if any, downward gradient within the glacial till.

From OK28 to the east end of the cross-section involves an area with thick lacustrine deposits overlying glacial till of presumed slow permeability. From 22,000 to 28,000 feet east of the western boundary of the cross-section, there is a sand ridge which

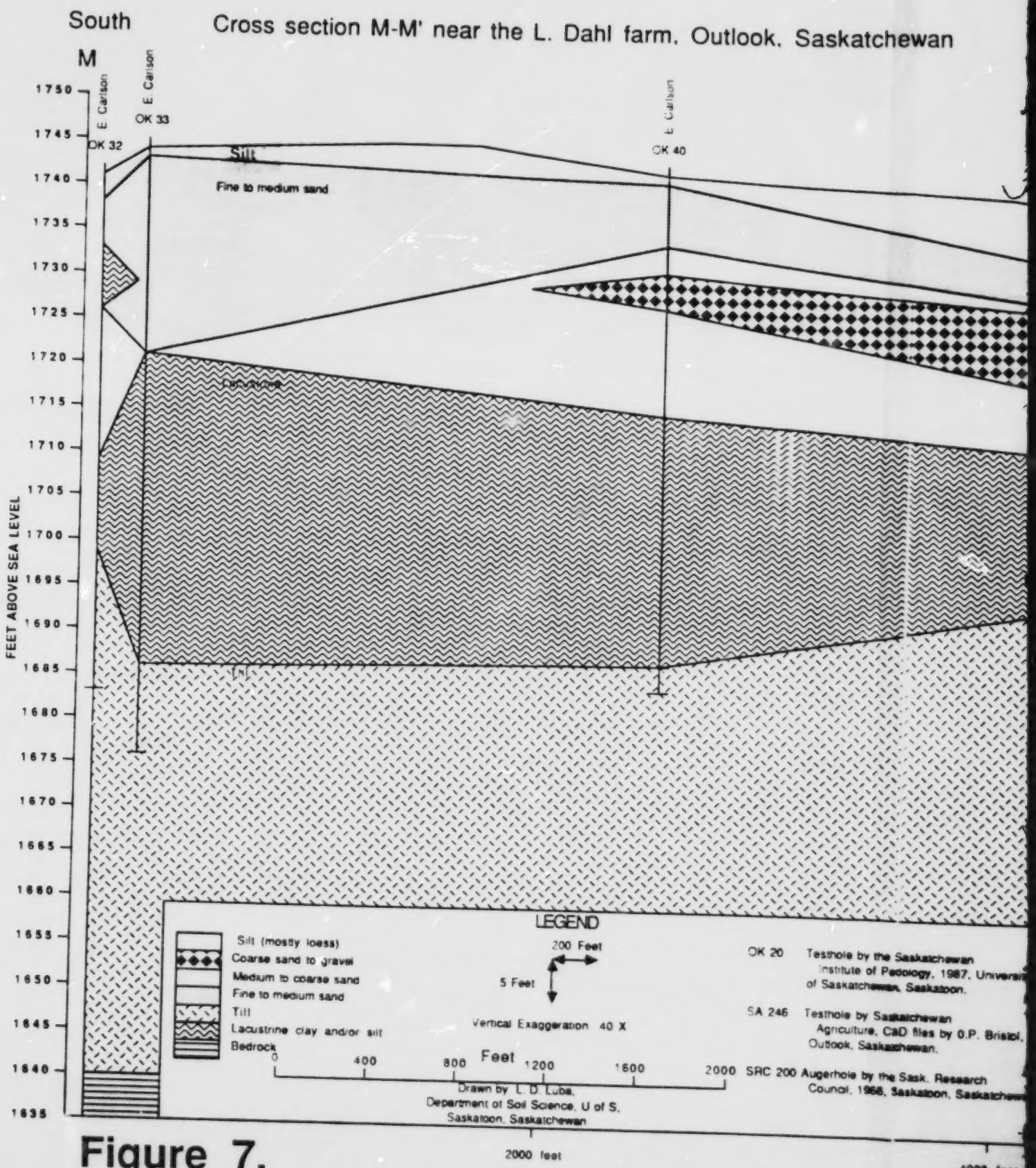
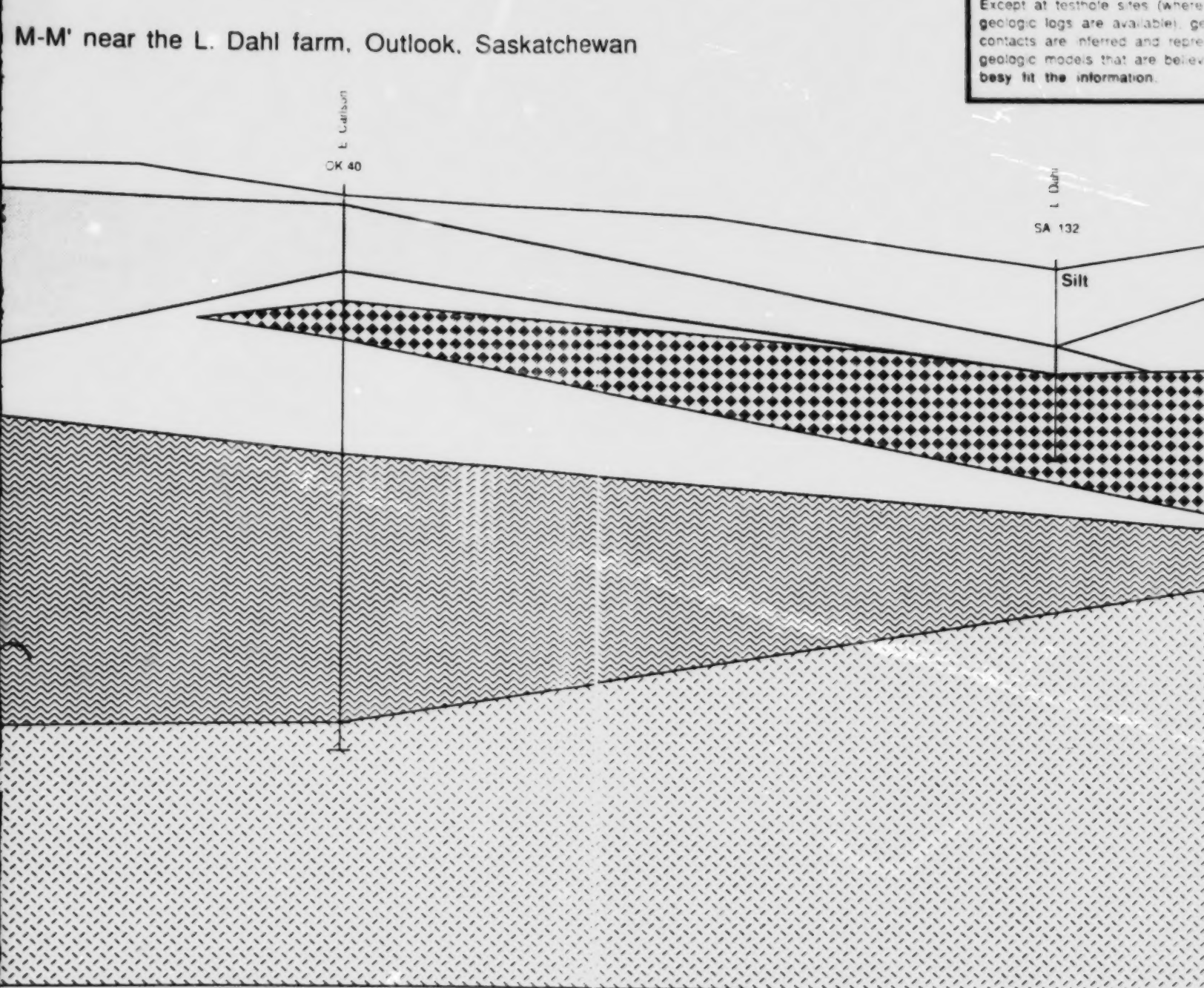

South
M
Cross section M-M' near the L. Dahl farm, Outlook, Saskatchewan
E. Carlson
OK 32
E. Carlson
OK 33
E. Carlson
OK 40
Silt
Fine to medium sand
Lacustrine
Till
FEET ABOVE SEA LEVEL
1750
1745
1740
1735
1730
1725
1720
1715
1710
1705
1700
1695
1690
1685
1680
1675
1670
1665
1660
1655
1650
1645
1640
1635
LEGEND
Silt (mostly loess)
Coarse sand to gravel
Medium to coarse sand
Fine to medium sand
Till
Lacustrine clay and/or silt
Bedrock
200 Feet
5 Feet
Vertical Exaggeration 40 X
0
400
800
Feet
1200
1600
2000
Drawn by L. D. Lube,
Department of Soil Science, U of S,
Saskatoon, Saskatchewan
OK 20 Testhole by the Saskatchewan Institute of Pedology, 1987, University of Saskatchewan, Saskatoon.
SA 246 Testhole by Saskatchewan Agriculture, CaD files by O.P. Bristol, Outlook, Saskatchewan.
SRC 200 Augerhole by the Sask. Research Council, 1966, Saskatoon, Saskatchewan
2000 feet
4000 feet

Figure 7.

M-M' near the L. Dahl farm, Outlook, Saskatchewan

NOTE OF LIMITATION

Except at testhole sites (where geologic logs are available), ge contacts are inferred and repre geologic models that are believ **besy fit the information.**



LEGEND

200 Feet
5 Feet
Vertical Exaggeration 40 X

400 800 Feet 1200 1600 2000

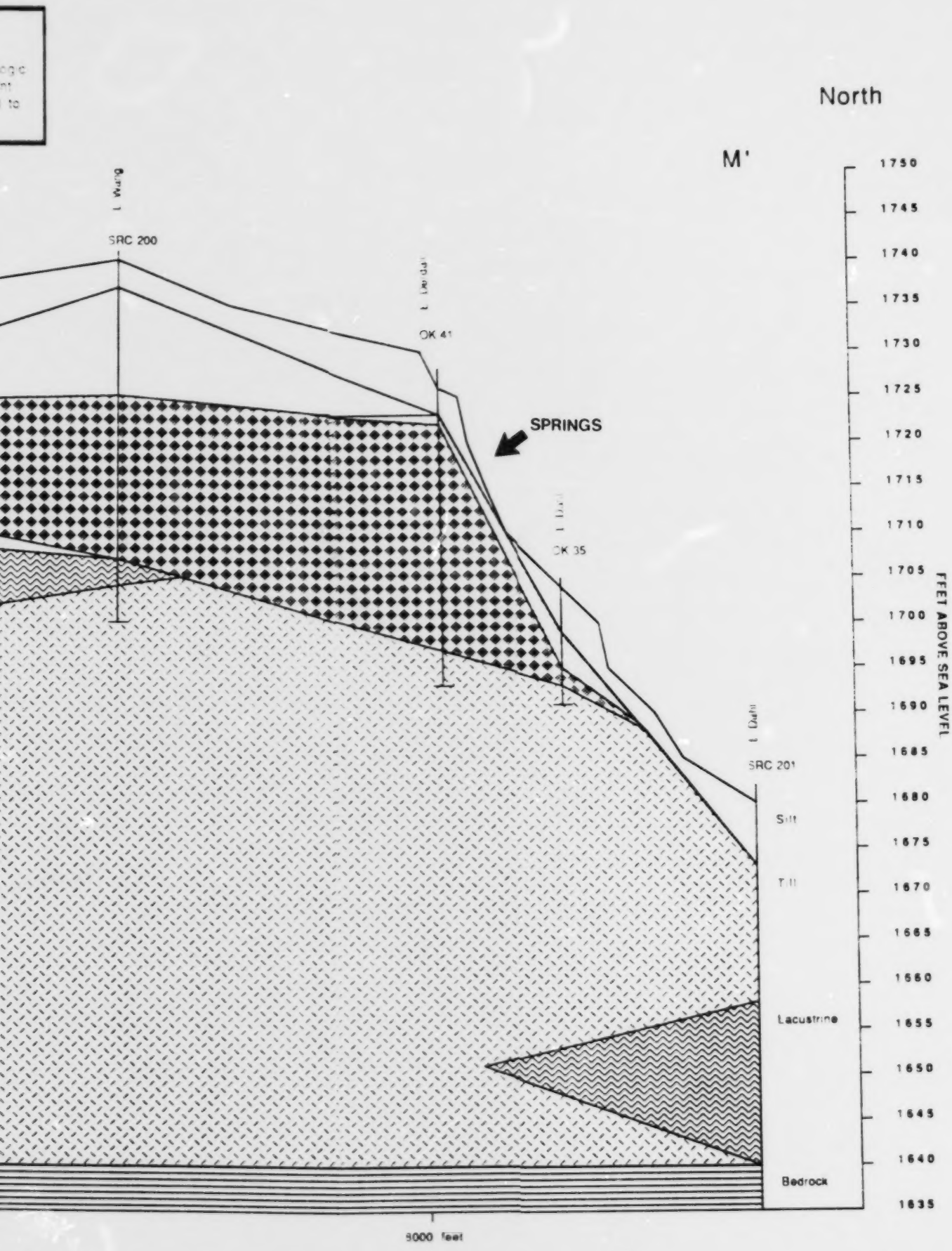
Drawn by L. D. Luba,
Department of Soil Science, U of S,
Saskatoon, Saskatchewan

OK 20 Testhole by the Saskatchewan Institute of Pedology, 1987, University of Saskatchewan, Saskatoon.

SA 246 Testhole by Saskatchewan Agriculture, C&D files by O.P. Bristol, Outlook, Saskatchewan.

SRC 200 Augerhole by the Sask. Research Council, 1966, Saskatoon, Saskatchewan

2000 feet 4000 feet 6000 fee


North
M'
SRC 200
OK 41
SPRINGS
OK 35
SRC 201
Silt
Till
Lacustrine
Bedrock
9000 feet
1750
1745
1740
1735
1730
1725
1720
1715
1710
1705
1700
1695
1690
1685
1680
1675
1670
1665
1660
1655
1650
1645
1640
1635
FEET ABOVE SEA LEVEL

would most probably be responsible for a significant lateral movement of water from west to east, impacting on farm land in the region of OK53.

Q-Q': (Figure 9) From testholes C110 to SRC10 is a region of thin lacustrine deposits overlying glacial till which is the fill associated with the Outlook Valley. The till included many sand "stringers" which at testhole C142 would be interpreted as an intertill aquifer. The SRC testholes did encounter sand lenses within the till. At SRC10 the piezometric level from a sand lense in the till, at a depth of about 25 feet, was above the water table. Any further investigations in this area should explore the possibility that the intertill sand and gravel at testhole C142 has continuity in the same direction as the Outlook Valley; i.e. north - south.

From SRC1 to OK73 is an area of shallow lacustrine deposits, overlying shallow till deposits, overlying bedrock at shallow depths. The bedrock is disturbed and this would promote lateral movement leading to a lack of downward gradient, and in some cases, an upward gradient. The water chemistry in the piezometer at OK73 shows the presence of highly mineralized water with a moderate SAR which would be expected from water that had circulated through glacial till deposits and bedrock.

P-P': (Figure 10) This cross-section is at the south end of the project. At OK72 an intertill aquifer with head close to the soil surface was encountered. This aquifer is fine to medium sand. We do not interpret it as being an aquifer of major extent and because of the fine sand would not anticipate pumping of the aquifer to be a feasible reclamation possibility.

Q-Q': (Figure 11) This cross-section shows the maximum expression of artesian influence from aquifers within the glacial till. At OK65 an intertill sand was encountered with a static water level 10 feet above ground surface. The water chemistry at this site shows water typical of intertill aquifers with an EC of 1.72 and an SAR of 2.9 and a very low chloride concentration. At testhole OK66 a fine sand of only moderate permeability was also found

to have head above ground surface. The more mineralized water chemistry at OK66 is likely due to the fact that the piezometer installation is actually completed within the till above the actual aquifer. Because of sand collapsing, it was not possible to install the piezometer directly in the aquifer. This aquifer is part of the poorly developed system of sandy till which locally comprises an aquifer and in total would have continuity to the upland moraine located in the eastern half of Range 7 and eastward. Immediately east and north of OK66, shallow augering by hand revealed the presence of near surface sand and a shallow water table in that sand.

Hydraulic rotary testholes were drilled on the western embankment of the Broderick Reservoir for the specific purpose of determining whether or not permeability existed in the bottom of the Reservoir that could be directly connected with the intertill aquifer. Testhole OK111 (not shown in this cross-section) showed no evidence of permeability from the surface of the embankment to bedrock. Testhole OK112 (on cross-section) does show the existence of a small sand layer at the bedrock surface. However, this is overlain by several meters of slowly permeable glacial till. Our general conclusion based on testholes OK111, OK112, OK104 and testholes of Keith and Associates is that there is no direct "pipeline" from the Broderick Reservoir to the Kuffner and Gross sites.

The soil salinity present at OK65 is definitely of long standing and has been present prior to any irrigation development. The assessment data from 1943 shows the presence of salinity on that quarter section at that time (Appendix A).

Several testholes were drilled on NW5-29-7-W3 (Gross site). These testholes showed that the intertill aquifer causing salinity at that particular site had considerable variation on a local basis. Within an area of only a few acres, the aquifer varied from well developed medium sand, several meters thick, to fine interbeds barely discernible in drilling. Thus, the possibility of any drainage by pumping the aquifer seems remote.

R-R': (Figure 12) This cross-section is similar to Q-Q' but crosses the Broderick Reservoir and shows the nature of the bottom of the Reservoir. It shows the significant depth of slowly permeable glacial till within the Reservoir.

S-S': (Figure 13) All information for this cross-section came from existing file information. From testhole SA168 to testhole SA292 is an area with a significant depth of near surface sand. The Barrich farm well (SRC68) is completed in the Judith River Formation with static level over 100 feet below ground surface. East of testhole SSSG25 is a region of shallow lacustrine deposits overlying glacial till of presumed low permeability.

5.2.2 Description of specific areas

During the course of the investigation it became obvious that there were at least three distinct areas with separate stratigraphy, hydrogeology and salinization/waterlogging mechanisms. The three areas will have distinctly different reclamation possibilities. The location of the three areas is presented in Figure 14 for the land within SSRID #1.

AREA 1: Area 1 includes two separate components. The first portion of Area 1 lies north and east of Outlook. It is characterized by generally more than 10 feet of coarse sand and/or fine gravel deposits overlying finer textured clay loam to clay lacustrine material and/or till. In some cases, the coarse material sits directly on till and in other cases there may be several feet of fine textured lacustrine material between the coarse sand and the till. The second portion of Area 1 lies largely within 31-7-W3, in the area generally referred to by the local farmers as "sand point country".

The boundary between Area 1 and the remainder is reasonably well established by existing testhole information and we would not anticipate it to change much with the acquisition of additional information. The boundary between Areas 2 and 3 cannot always be established by shallow (10-20 feet) drilling and hence is much less precise. We would anticipate that there could be significant change in the exact location of the Areas 2-3 boundary as additional information becomes available.

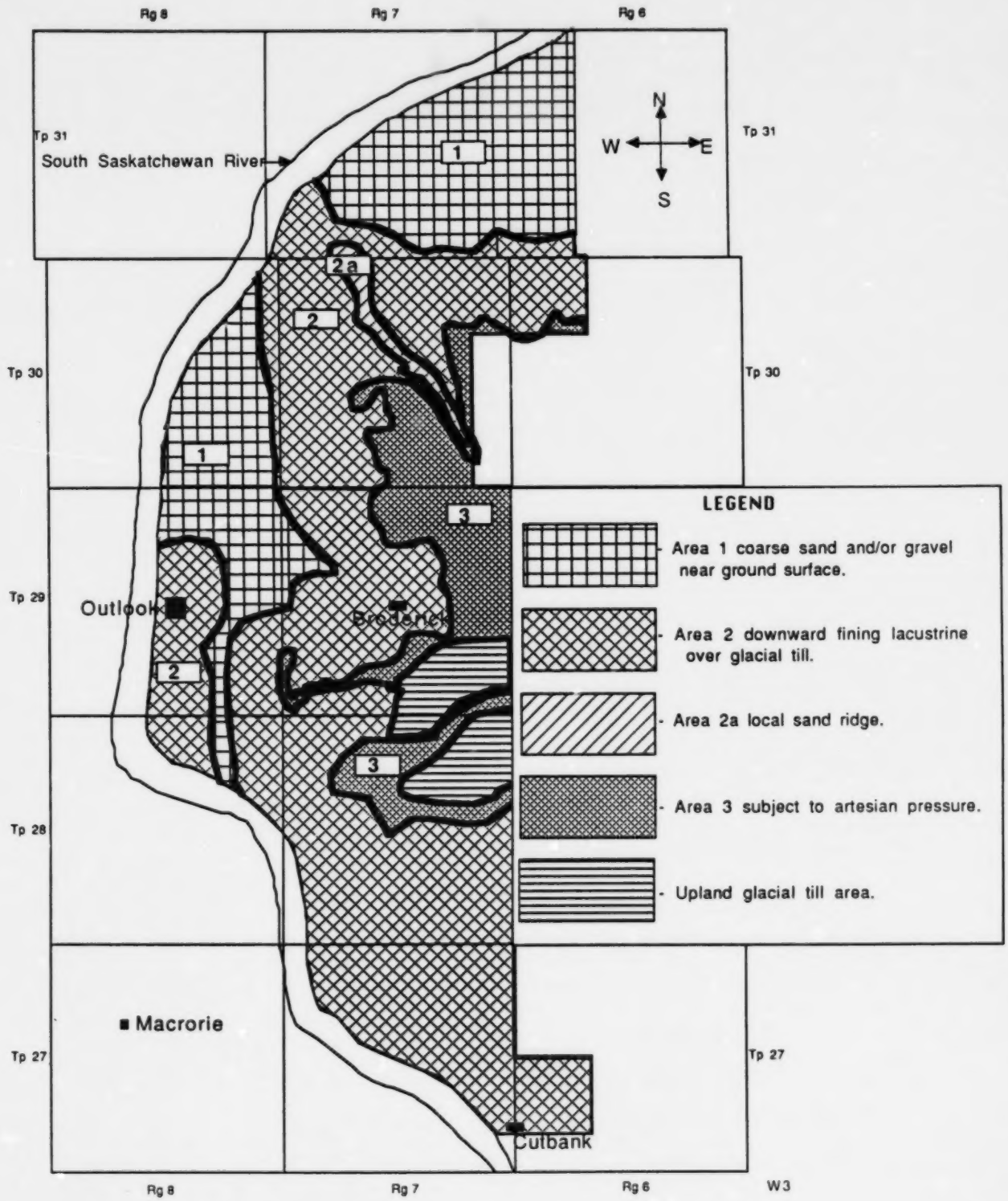


Figure 14. Map showing specific areas with different salinization/waterlogging mechanisms.

Area 1 comprises a situation in which the problem is one of waterlogging more than soil salinity *per se*. The presence of adequate permeability at very shallow depths results in very significant groundwater flow within the area. In some cases, the slope of the less permeable material results in discharge to the Saskatchewan River Valley in the form of springs. In Township 31, Range 7, in particular, some of these discharge springs have been active before the advent of cultivation, and certainly before any irrigation activity. In cases where the springs are capable of removing any excess water, the water table remains below the root zone and no problems occur.

However, in this area, with the advent of irrigation the input of water to the near surface water table became larger than the capability of the system to transmit this water laterally and out of the area through springs, or to transmit it downward through slow seepage. Thus, the water table came near to the soil surface, creating waterlogging problems and some surface salinity. Typically, in this area, the salt load in the soil profile is low. Because the salts are all concentrated in the surface they do create some soil salinity problems, but the total salt load is orders of magnitude lower than natural soil saline areas. Very little movement of salt need take place to reclaim saline soils in Area 1.

In at least one location (NE14-36-29-8-W3 and SE3-1-30-8-W3) we have documented the existence of a true alkali soil situation. This results from the rapid movement of water and evaporation. The water is moving through coarse sand and gravel deposits and does not move through any lacustrine or till material and hence does not pick up sulphate salts as is the case in 'normal' saline areas. Thus, sodium accumulates along with carbonate leading to a sodium carbonate, high pH, true alkali situation. Soil analysis from hand auger samples in this area are documented in Table 3.

In a true alkali soil situation chemical amendments such as addition of acid or acid-forming material like sulphur may be required in the reclamation process. However, we do

Table 3. Soil analyses from hand auger samples in a 'true' alkali soil*.

Legal location (Surface condition)	Depth (feet)	pH	1:1 E.C. dS/m Suspension	1:1 E.C. dS/m Extract	Na	Ca + Mg	K	Cl	Total cation	Total salt	SAR
					meq/l						
NE14-36-29-8-W3 (grass)	0-1	8.3	1.28	2.03	13.1	3.0	0.7	0.4	16.8	20.3	11
	1-2	8.0	0.54	0.75	3.1	2.6	0.3	0.3	6.0	7.5	3
	2-3	8.0	0.45	0.56	1.6	2.7	0.2	0.2	4.5	5.6	1
	3-4	8.0	0.45	0.49	1.3	2.6	0.2	0.2	4.1	4.9	1
NE14-36-29-8-W3 (patterned ground)	0-1	9.2	1.99	3.03	28.7	0.5	0.9	1.2	30.1	30.3	57
	1-2	8.7	0.89	1.41	11.2	0.8	1.1	0.3	13.1	14.1	18
	2-3	8.7	0.83	1.27	11.3	0.5	0.8	0.2	12.6	12.7	23
	3-4	8.7	0.68	1.10	9.2	0.5	0.6	0.3	10.3	11.0	18
SW3-1-30-8-W3 (white crust)	0-1	8.8	1.57	2.55	20.8	1.5	0.7	0.9	23.0	25.5	24
	1-2	8.4	0.84	1.22	7.6	1.8	0.4	0.2	9.8	12.2	8
	2-3	8.2	0.50	0.70	3.3	1.8	0.3	0.2	5.4	7.0	4
	3-4	8.3	0.42	0.58	2.7	1.7	0.3	0.2	4.7	5.8	3
SW3-1-30-8-W3 (white crust, bare, lumpy)	0-1	9.2	1.87	2.86	25.5	0.7	0.9	1.2	27.1	28.6	43
	1-2	8.6	1.58	2.56	21.0	0.9	0.6	0.8	22.5	25.6	31
	2-3	8.7	1.31	2.05	15.9	0.9	0.6	0.3	17.4	20.5	24
	3-4	8.6	1.33	2.32	19.1	0.8	0.6	0.4	20.5	23.2	30

*Results reported are mean of dupicate analyses.

not recommend any immediate move to such steps. The main problem is still one of a high water table and the reclamation process must deal with that problem in the first instance.

The presence of very highly permeable material at very shallow depths throughout Area 1 leads to many possibilities for drainage. Deepening of natural surface drains is one possibility but this creates some engineering challenges because of the caving in that takes place in ditches in coarse material.

Drainage with perforated plastic pipe is very effective in such materials and there are already existing installations that demonstrate this. Well point, or other dewatering methods, may be a possibility where the coarse sand/gravel is sufficiently thick.

IN SUMMARY, AREA 1 IS A LOCATION WHERE THERE ARE MANY DIFFERENT POSSIBILITIES TO INCREASE THE WATER FLOW OUT OF THE SYSTEM AND HENCE RECLAIM THE SOIL.

AREA 2: Area 2 consists of downward fining lacustrine deposits overlying glacial till. In some cases there may be up to a few feet of medium to fine sand above the finer textured lacustrine materials. However, within Area 2 there are few cases with sufficient depth of sufficiently coarse material to provide easy drainage.

Area 2 is characterized by very low pressure heads in the underlying aquifer systems such as the Conquest or Outlook Valley or the Judith River Formation. There is no deep seated regional artesian pressure system operating within this particular area. In Tp 27, Rg 7, W3 and the southern half of TP 28, Rg 7, W3, local intertill aquifers were encountered and in at least one case (OK72, Figure 9), the pressure head was near the surface. In addition, Barteski (1984) found intertill sands along the M1 canal. However, we conclude that artesian pressure is not a major salinization mechanism in this area.

Area 2 includes many situations in which historical data such as soil survey, Municipal Assessment, air photos or farmer experience show little or no evidence of soil salinization. In these areas, under native and non-irrigated farming practices, the main impact to the water table system was through sloughs (Figure 15). In some situations minor water table accumulations may have been present around sloughs and there were probably some subsoil saline conditions in rings around sloughs. However, under the pre-irrigated condition the downward movement was sufficient to avoid any serious water table buildup and salinization problems.

AREA 2 IS A LOCATION WHERE THE POSSIBILITIES FOR REMOVING EXCESS WATER FROM THE SYSTEM ARE LIMITED. THUS, THE LONG TERM STRATEGY IN AREA 2 MUST BE TO TAKE EVERY POSSIBLE STEP TO REDUCE THE INPUT OF EXCESS WATER TO THE GROUNDWATER TABLE.

Area 2 contains one subarea with special consideration. This area is identified in Figure 14 as Area 2a. It consists of a northwest to southeast sand ridge system with the

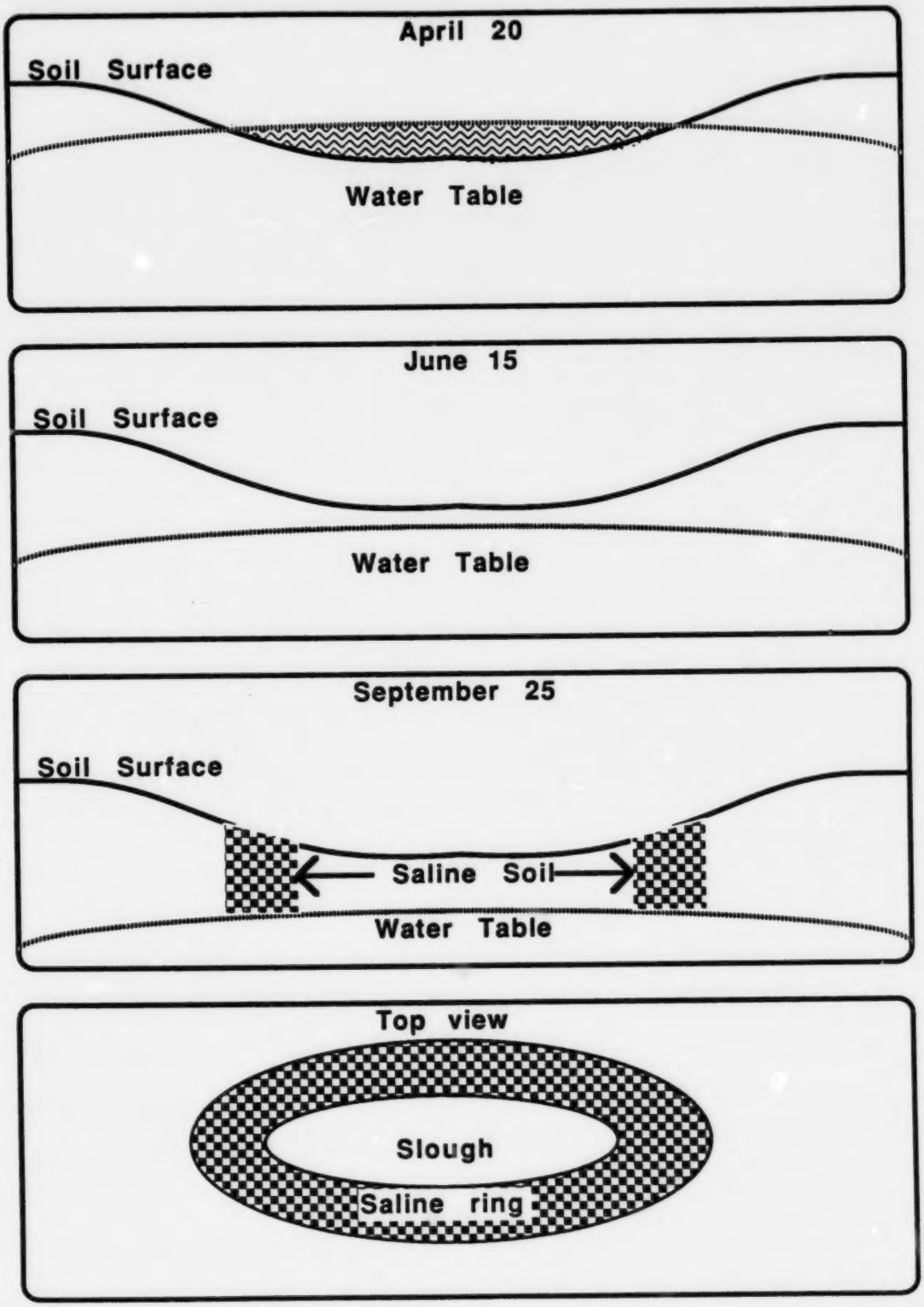


Figure 15. Schematic diagram of salinization 'rings' around sloughs.

northwest point being in Section 5-31-7-W3 and the southeast corner being in Section 11-30-7-W3. This sand ridge acts as a recharge focus point and saline discharge areas can be found around the perimeter of this ridge. Any irrigation, canal or ditch leakage or other input to the groundwater that takes place on this ridge will, in time, impact on soil salinity around the perimeter.

AREA 3: This area occurs along the eastern edge of SSRID #1 (Figure 14) and continues in a northeast direction from Broderick to Hanley and in an easterly direction to within a few miles of Kenaston. The reader is reminded of the previous statement pointing out that the boundary separating Area 2 from Area 3 may be subject to revision as more information becomes available.

Area 3 is characterized by the presence of artesian pressure from an extremely complex series of geologic features. These include:

(1) Intertill aquifers, generally at shallow depths. These intertill aquifers occur as "fingers" that reach out from the glacial till moraine upland to the east. Examples of this situation occur on the G. Gross (NW5-29-7-W3) and the A. Kuffner (SE5-29-7-W3) farms.

(2) The second system includes sands and gravels of the Empress group. This is a formation situated between the glacial deposits and bedrock. An example of this occurs just northeast of Broderick on the Gifford farm (26-29-7-W3).

(3) The third type of aquifer is the Ardkenneth member of the Bearpaw Formation. The best example of this occurs along Highway #219 north of Highway #15. The Morken well is in this formation. The flowing well at the south end of Broderick marsh (SW18-30-6-W3) is also assumed to be in that formation.

(4) The final feature is one that occurs south of Broderick and consists of various sandy members within the Bearpaw Formation that provide sufficient permeability to create an upward directed head. The area mapped in the original soil survey as Tuxford clay

loam within portions of Sections 28 and 29, Townships 28, Range 7, W3 results from this particular hydrogeology condition.

IN ALMOST ALL CASES WITHIN AREA 3, SOIL SALINITY IS A CONDITION WHICH NOT ONLY PREDATED IRRIGATION, IT PREDATED CULTIVATION. IN MOST OF THESE AREAS SOIL SALINITY AND/OR SOLONETZIC SOIL DEDUCTIONS CAN BE FOUND ON MUNICIPAL ASSESSMENT SHEETS AS FAR AS BACK AS THE 1940'S.

POSSIBILITIES FOR RECLAMATION IN AREA 3 ARE LIMITED.

6. Conclusions and Management Implications

While several different mechanisms of soil salinization and waterlogging have been identified in this work, it can all be reduced to one simple arithmetic principle. Waterlogging and associated soil salinity occur as a result of more water being applied into the system than can be lost by either drainage to greater depths or lateral movement out of the system. Thus, the overall management strategy must involve either some way to remove excess water from the system or a strategy to ensure that less water is applied into the system. Thus, while the details can be quite complex, and at times seem confusing, the principles are very simple and easily understood.

AREA 1

Problems in Area 1 are mostly waterlogging rather than soil salinity. In this area inputs to the groundwater system will be through leakage of canals in some instances, but probably the greater volume of water results from a combination of irrigation and irrigation return flows. Within Area 1 there are at least two specific situations that the authors are aware of where return flows enter a ditch and simply disappear.

While possibilities do exist for drainage through improved surface drains, buried perforated plastic pipe or perhaps well points, the first strategy should be to reduce the water input by lining canals or replacing canals with pipe. Irrigation management should avoid excess input of water to the water table and balance supply as carefully as possible to avoid any excess return flows.

AREA 2

In Area 2 most of the extra input to the groundwater system is likely through leaky canals and drain ditches. Contributions through irrigation will be less because many of the soils in this area are finer with greater water holding capacity and the possibility of excess irrigation is reduced. The exception to this statement is in the northwest to southeast trending sand ridge described earlier (Area 2a - see Figure 14). In this area excess irrigation

on the sand ridge could act as a very definite and significant input to the groundwater system. Other areas with sandy surface soils should also be considered.

Management emphasis in Area 2 should be to minimize inputs of water to the system by lining canals or replacing canals with pipe, carefully balancing of flows and perhaps lining drainage ditches.

AREA 3

Area 3 includes some examples where soil salinization is a geologic fact and irrigation should not have taken place in the first instance. We recommend that these areas be planted down to permanent forage cover and attempts at annual crop production be discontinued. This is particularly true along certain areas of the M1 canal where seepage problems have rendered the land barren. In at least one of these areas a salt tolerant forage species has been established and by surface appearance it is "reclaimed". The salt load is almost all still present, but the growth of the grass covers it up and essentially removes the problem from the minds of people driving by.

7. Recommendations

In beginning the recommendations it is well to repeat the fundamental conclusion and basic principles involved. Waterlogging and soil salinity problems result whenever the input of water into the groundwater system is greater than the system can absorb through deep drainage or lateral movement out of the system. Thus, as an overall management strategy there are only two basic principles to adhere to. Either water must be removed from the system or management practices must be put in place to reduce the input of water into the system. With this basic principle in mind we recommend the following:

(1) That SSRID #1 place an immediate and total moratorium on further irrigation development until such time as a long term management strategy is in place.

(2) That the water table monitoring program, discontinued in 1983, be reinstated. At approximately 100 locations in SSRID #1 and 50 locations in the Conquest area, the sites can be selected from the existing water table network and new installations should be made in accordance with the specifications in Fig. 16. Both old and new installations could be monitored for about 1-2 years. In this way, it would be possible to determine the historic records that are reliable.

(3) That SSRID #1 work with Saskatchewan Water Corporation to develop a long term management strategy, keeping in mind the three very different situations identified in this report. We see no point in investing funds in engineering works to try to maintain situations that in the long term will not be viable. It is important that the funds be expended on areas that are in fact reclaimable and that can maintain productivity for generations to come.

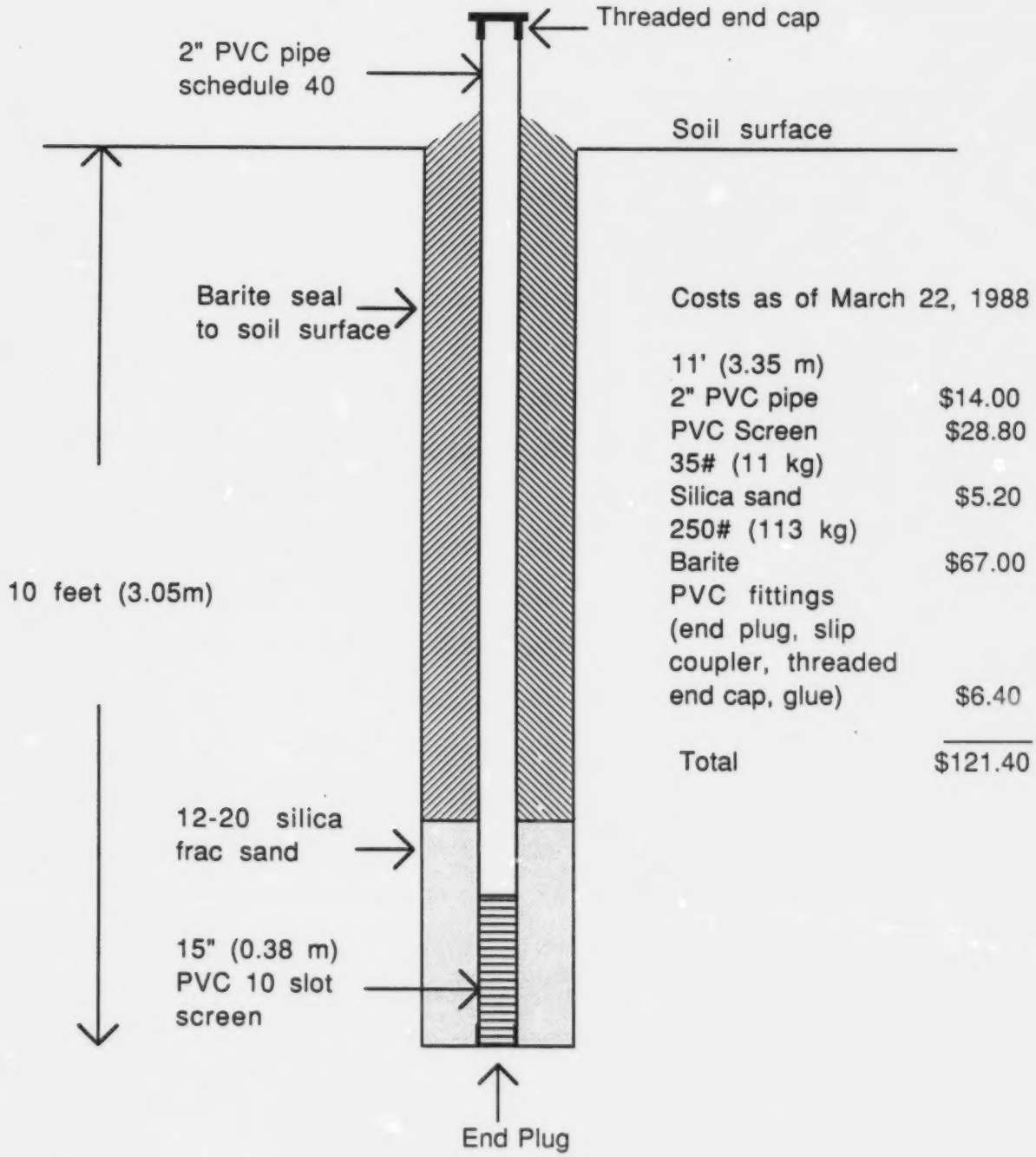


Figure 16. Recommended shallow piezometer installation

(4) That regardless what details are worked out within the overall management strategy, it is certain that the cost of these will be beyond the reach of the individual land owner or of the operating funds associated with SSRID #1. We recommend that SSRID #1 immediately approach federal and provincial governments for support to implement the management strategies developed.

Literature Cited

Acton, D.F., Clayton, J.S., Ellis, J.G., Christiansen, E.A., and Kupsch,W.O. 1960. Physiographic Divisions of Saskatchewan. Saskatchewan Soil Survey, Saskatchewan Research Council, and Geology Department, University of Saskatchewan, Saskatoon, Canada.

Barteski, L. 1984. M1 Irrigation canal seepage control investigations. Mimeo report, pp 37, 10 figures, Saskatchewan Water Corporation, Outlook, Saskatchewan.

Cameron, D.R., de Jong, E., Read, D.W.L., and Oosterveld, H. 1981. Mapping salinity using resistivity and electromagnetic inductive techniques. Can. J. Soil Sci. 61:67-78.

Campbell, J.W. 1983. Salinity and Groundwater Study for the South Saskatchewan River Irrigation District No. 1. Vol. 1 and 2, EPEC Consulting Western Ltd. 1500 - 4th Ave. Regina, Saskatchewan, S4R 8G8.

Christiansen, E.A. and W.A. Meneley. 1971. Geology and Groundwater Resources of the Rosetown Area (72-O). Saskatchewan Research Council Geology Division, Saskatoon, Saskatchewan.

Christiansen, E.A. 1984. Geology of the main canals in the Outlook area. Report 01101-001, Saskatchewan Water Corporation, Box 699, Outlook, Saskatchewan, S0L 2N0.

Christiansen, E.A. 1987. Geology of the Outlook irrigation project. E.A.Christiansen Consulting Ltd. Report No. 0117-001 to the Saskatchewan Institute of Pedology. University of Saskatchewan, Saskatoon.

Ellis, J.G., Acton, D.F., and Moss, H.C. 1970. The soils of the Rosetown Map area (72-O). Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, Saskatchewan.

Environment Canada. 1982. Canadian Climate Normals of Temperature and Precipitation, Volumes 2 and 3. Atmospheric Environment Service, Climatological Services Division, Downsview, Ontario.

Griffin, R.A., and Jurinak, J.J. 1973. Estimation of activity coefficients from the electrical conductivity of natural aquatic systems and soil extracts. Soil Sci. 116:26-30.

Harder, H. and Henry, J.L. 1986. Drift thickness of southern Saskatchewan, southeast sheet. Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, Saskatchewan.

Henry, J.L., Bullock, P.R., Hogg, T.J., and Luba, L.D. 1983. FarmLab salinity project report, site 83-6, Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon.

Henry, J.L., Harron, B., and Flaten, D. 1987. The nature and management of salt-affected land in Saskatchewan. Saskatchewan Agriculture, Soils and Crops Branch, Regina, Saskatchewan.

Hogg, T.J., and Henry, J.L. 1984. Comparison of 1:1 and 1:2 suspensions and extracts with the saturation extract in estimating salinity in Saskatchewan soils. Can. J. Soil Sci. 64:699-704.

Hogg, T.J., and Henry, J.L. 1985. The use of hydraulic rotary drill cuttings to determine the salt content of sediments. Can. Geotech. J. 22:249-253.

Kent, D.D. 1983. Canal Leakage Investigation, Section 19-30-5 W3 near Hanley, Saskatchewan. Clifton Associates Ltd. 340 Maxwell Cres., Regina, Saskatchewan, S4N 5Y5.

Mackay, B.R, and Maddox, D.C. 1936. Groundwater resources of the Rural Municipality of Rudy No. 284, Saskatchewan. Canada Department of Mines, Bureau of Economic Geology, Ottawa, Ontario, Canada.

Milham,P.J., Awad, A.S., Paul, R.E., and Bull, J.H. 1970. Analysis of plants, soils and waters for nitrate by using an ion-selective electrode. Analyst 95:751-757.

Mitchell, J., Moss, H.C., and Clayton, J.S. 1944. Soil Survey of Southern Saskatchewan, Soil Survey Report No. 12. Extension Division, University of Saskatchewan, Saskatoon, Saskatchewan.

Mortin, D.E. 1972. Report on the present status of geological investigations and subsurface drainage on the South Saskatchewan River Irrigation District. Saskatchewan Water Corporation, Outlook, File Report 901-10-8.

Peterson, R. 1954. Studies of Bearpaw shale at a dam site in Saskatchewan. Proc. Amer. Soc. Civil Eng. vol. 80, No. 476.

Rhoades, J.D. 1982. Soluble salts. In: A.L. Page et al., eds. Methods of Soil Analysis, Part 2. Chemical and microbiological properties. 2nd ed. Agronomy 9, Am. Soc. Agron., Madsion, Wis.

Richards, L.A. 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No. 60, United States Department of Agriculture, Washington D.C.

Straub, C.G.A. 1987. Seepage control investigations for South Saskatchewan River Project east side irrigation Sections 21 and 22-28-7 W3. P.F.R.A. Engineering Service, Regina, Saskatchewan.

Pollock, D.H. 1962. Geology of the South Saskatchewan River Project. Eng. J., pp 37-46.

Sawatsky, H.B. 1967. Composite seismic map. Saskatchewan Mineral Resources Files, Regina, Saskatchewan.

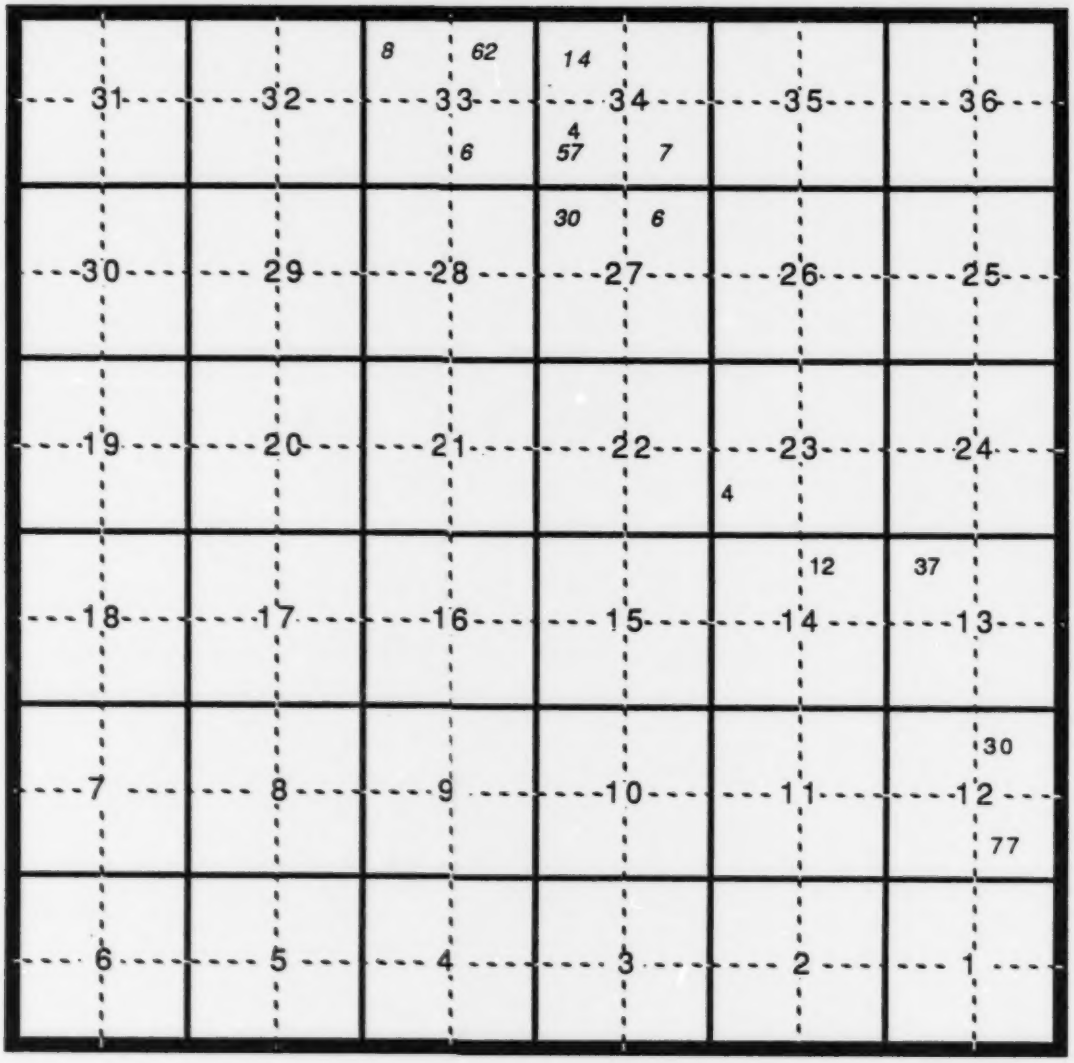
Scott, J.S. 1960. Surficial geology of the Elbow-Outlook Area, Saskatchewan, Canada, Unpublished Ph.D. Thesis, University of Illinois, U.S.A.

Stewart, R.J. 1983. Potentiometric surface map of the Rosetown (720) Map Area. Groundwater Division, Water Management Services, Saskatchewan Environment, Regina, Saskatchewan (now Saskatchewan Water Corporation, Moose Jaw).

APPENDIX A

Summary of salinity and solonetzic soil deductions from Municipal Assessment data

RM of Loreburn No.254 Tp.27 Range 6 West of 3.



1969 Municipal Land Assessment

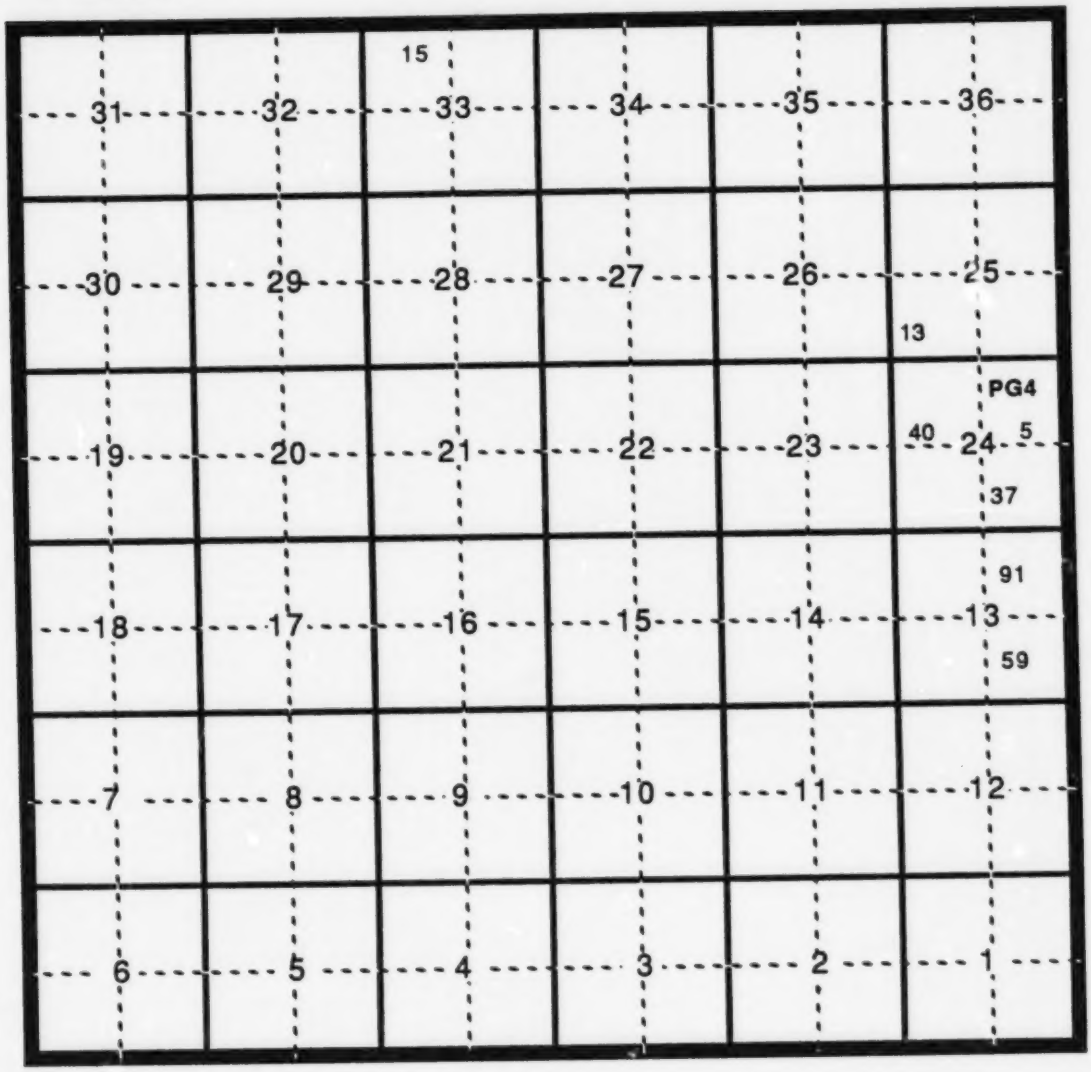
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Loreburn No. 254 Tp. 27 Range 7 West of 3.



1969 Municipal Land Assessment

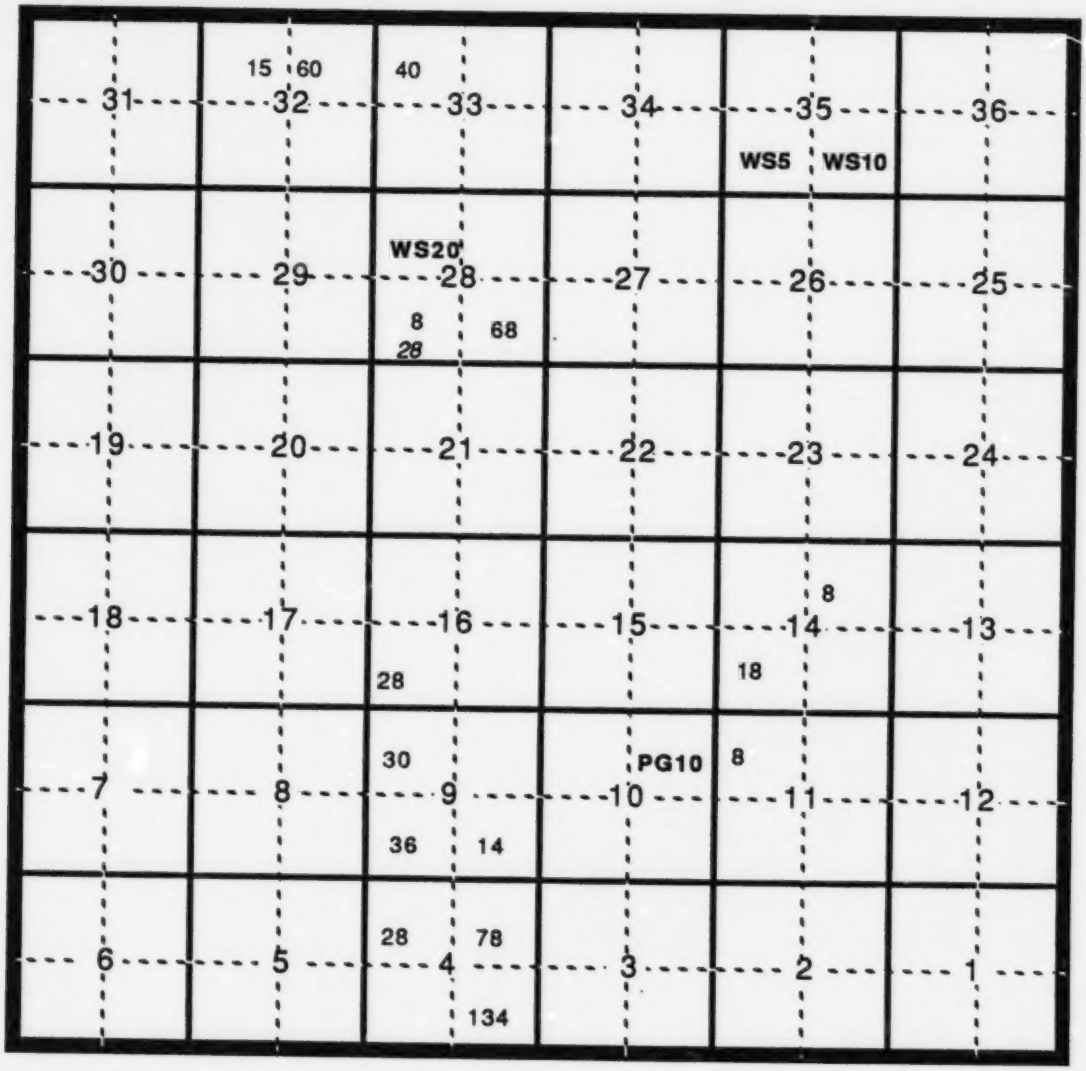
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No. 284 Tp. 28 Range 6 West of 3.



1971 Municipal Land Assessment

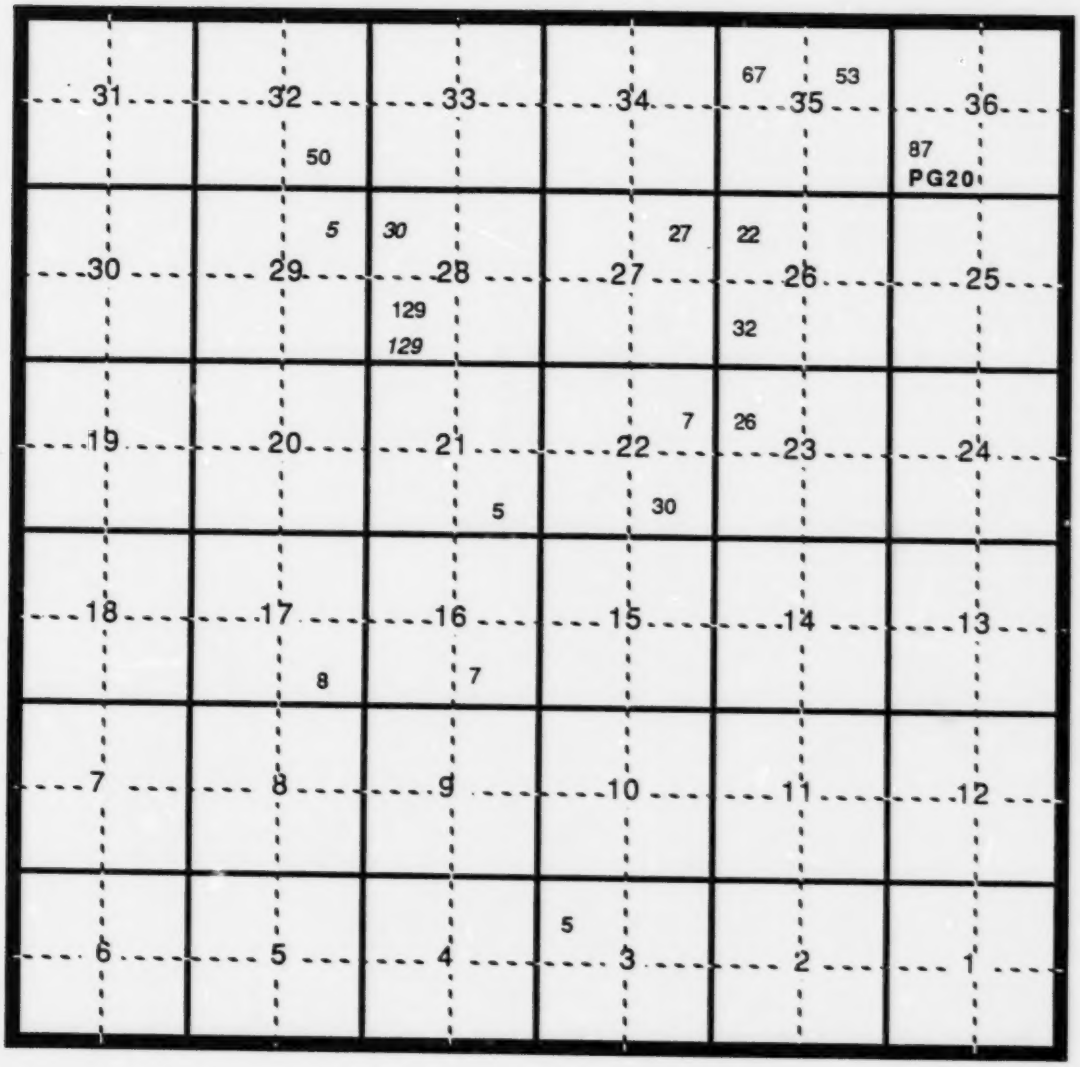
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No.284 Tp28 R7 West of 3



1971 Municipal Land Assessment

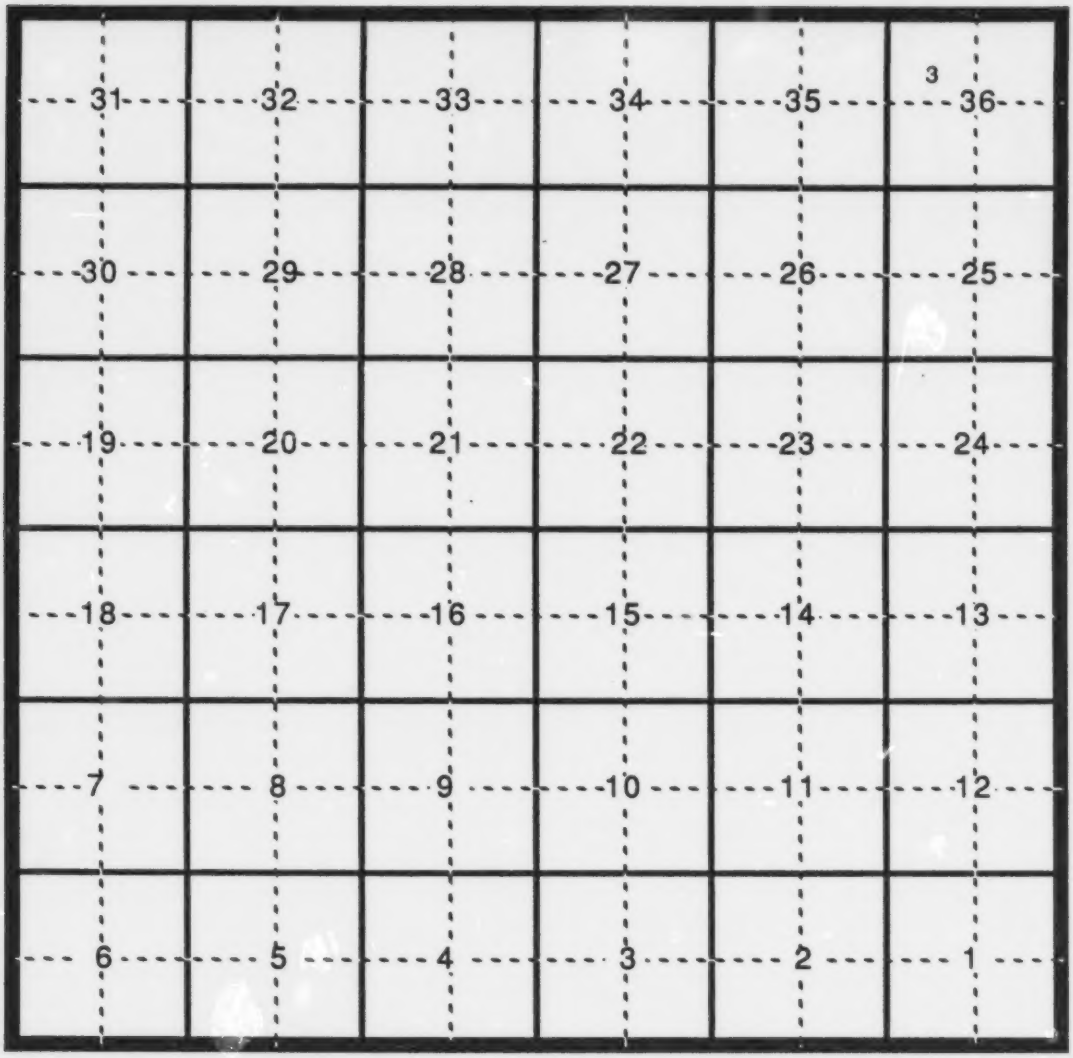
LEGEND

$$75 = \frac{\text{acres x salinity deduction}}{10}$$

$$\textit{75} = \frac{\textit{acres x solonetzic deduction}}{\textit{10}}$$

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No.284 Tp. 28 Range 8 West of 3.



1971 Municipal Land Assessment

LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No.284 Tp.29 Range 6 West of 3.

PG160 PG160		PG160	PG28 142	158	95	95	91	111	159	100	101
31		32	202	33		34		35		36	
112 133 PG60	PG160	PG90 165 185	50 156	91	111	88	92	109	159	106	108
PG32 145 145	PG90 134 141	132 195	126	94	93	90	96	31 151	151 151	162	60 PG60 123
30		29		28		27		26		25	
PG13 246 291	127 167	PG18 64 152	117	94	93	88	95	184 184		30 54	180 130
108 40	130	120	142	125	158	150	189	120			
19		20		21		22		23		24	
96	131	127	135	143	180 180	46 216	190	98			15
106	48	48	100	210	253	161	96	93			
18		17		16		32 15		93 14		13	40
20 133	22	16 19	87	127	96	60	21 162	102 102			
36			60			36	95 28	9 10		7	
7		8		9		10		11		12	
78		32	19					7	7		12
8		26						18	46	39	
6		5		4		3		PG 7 2		1	
	47	101	1.4	PG17 26		10				46	39

1971 Municipal Land Assessment

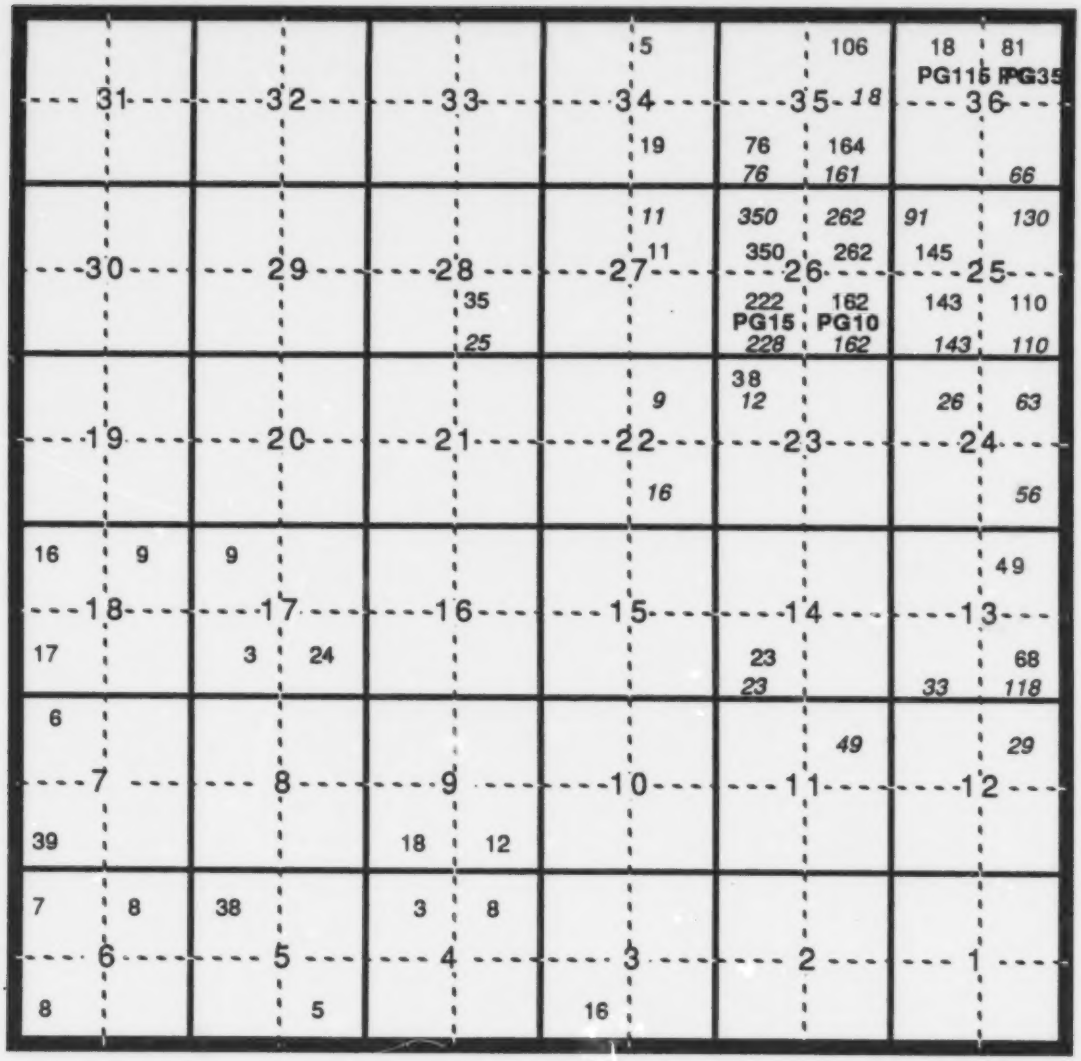
LEGEND

$$75 = \frac{\text{acres x salinity deduction}}{10}$$

$$75 = \frac{\text{acres x solonetzic deduction}}{10}$$

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of RUDY No.284 Tp. 29 Range 7 West of 3.



1971 Municipal Land Assessment

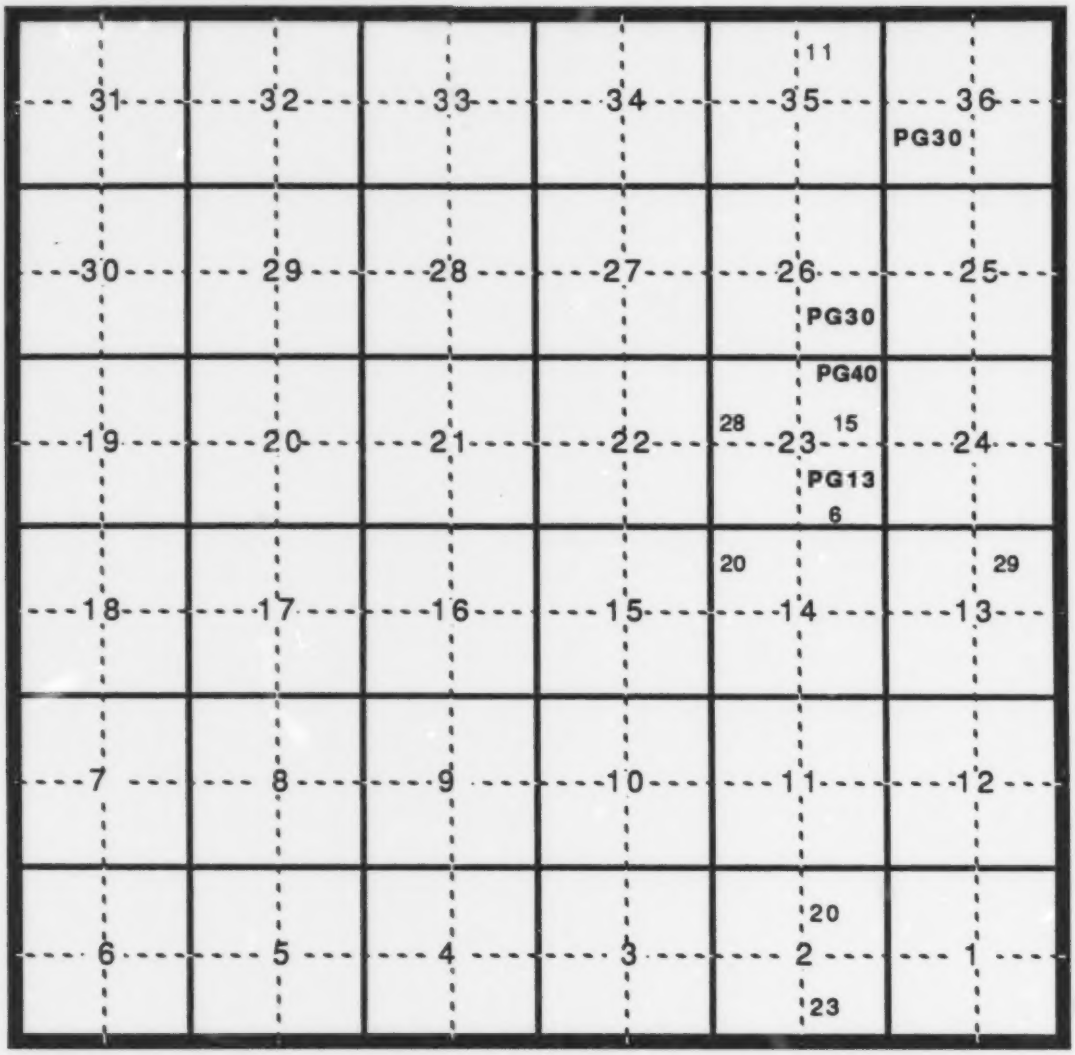
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No.284 Tp.29 Range 8 West of 3.



1971 Municipal Land Assessment

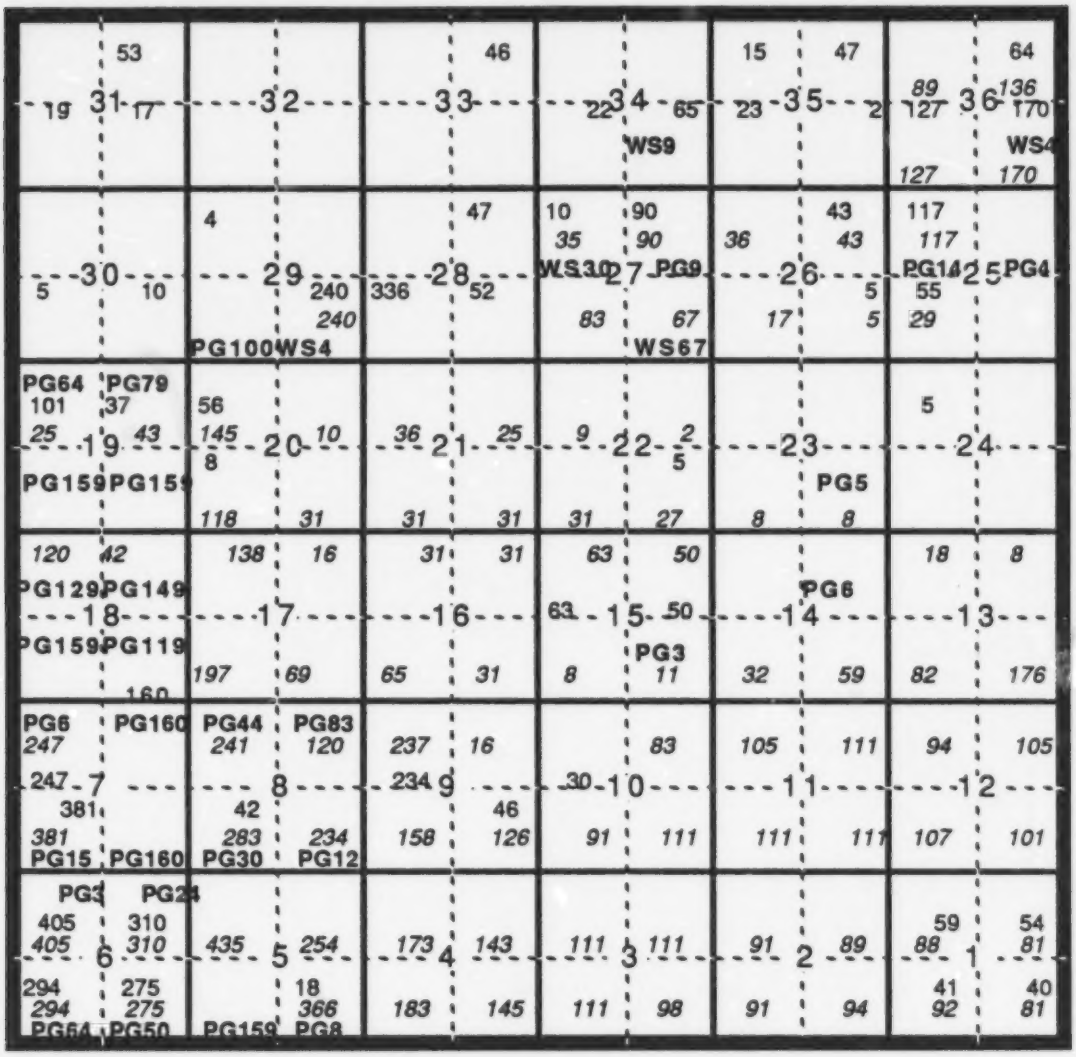
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No.284 Tp. 30 Range 6 West of 3.



1971 Municipal Land Assessment

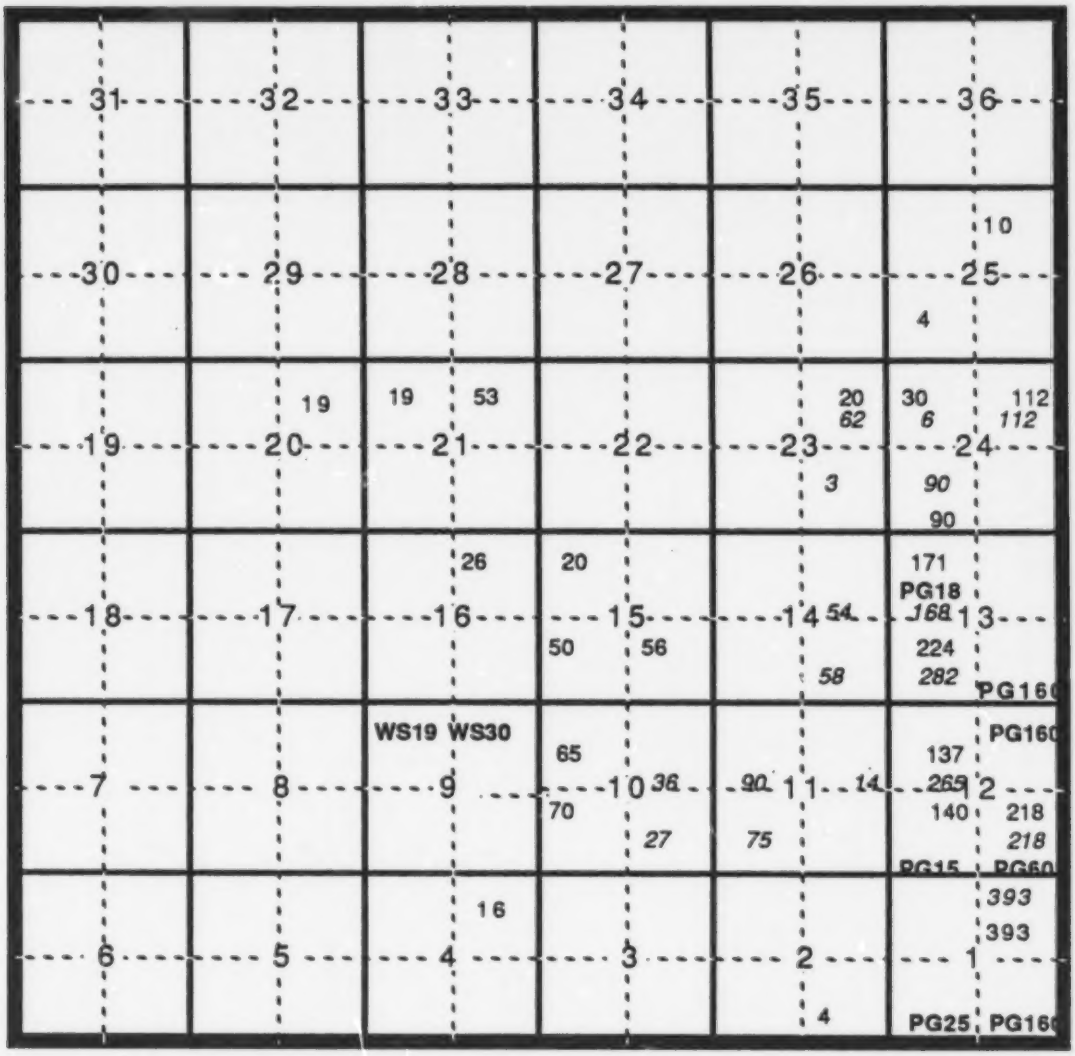
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of RUDY No. 284 Tp.30 Range 7 West of 3.



1971 Municipal Land Assessment

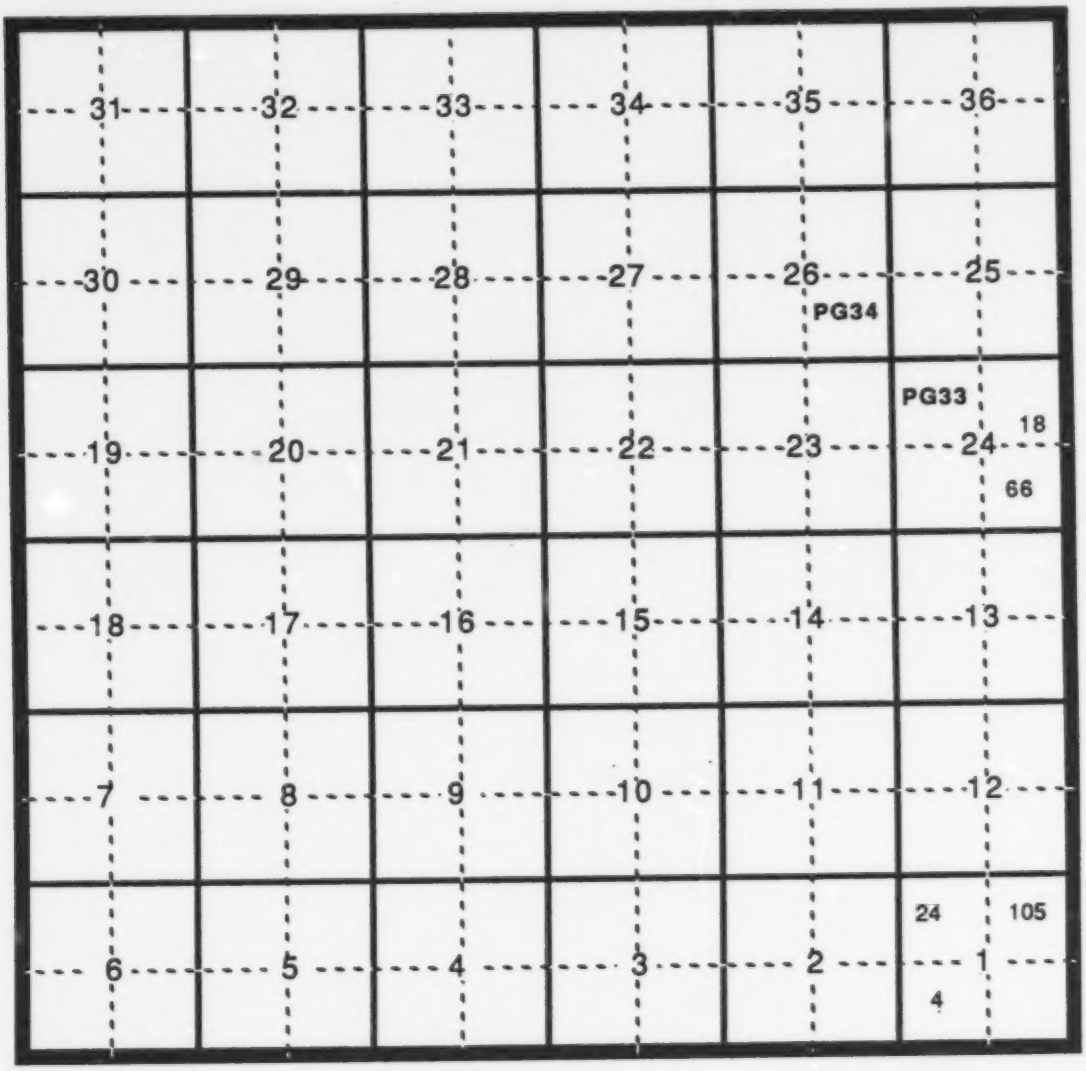
LEGEND

$$75 = \frac{\text{acres x salinity deduction}}{10}$$

$$\textit{75} = \frac{\textit{acres x solonetzic deduction}}{\textit{10}}$$

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of RUDY No.284 Tp.30 Range 8 West of 3.



1971 Municipal Land Assessment

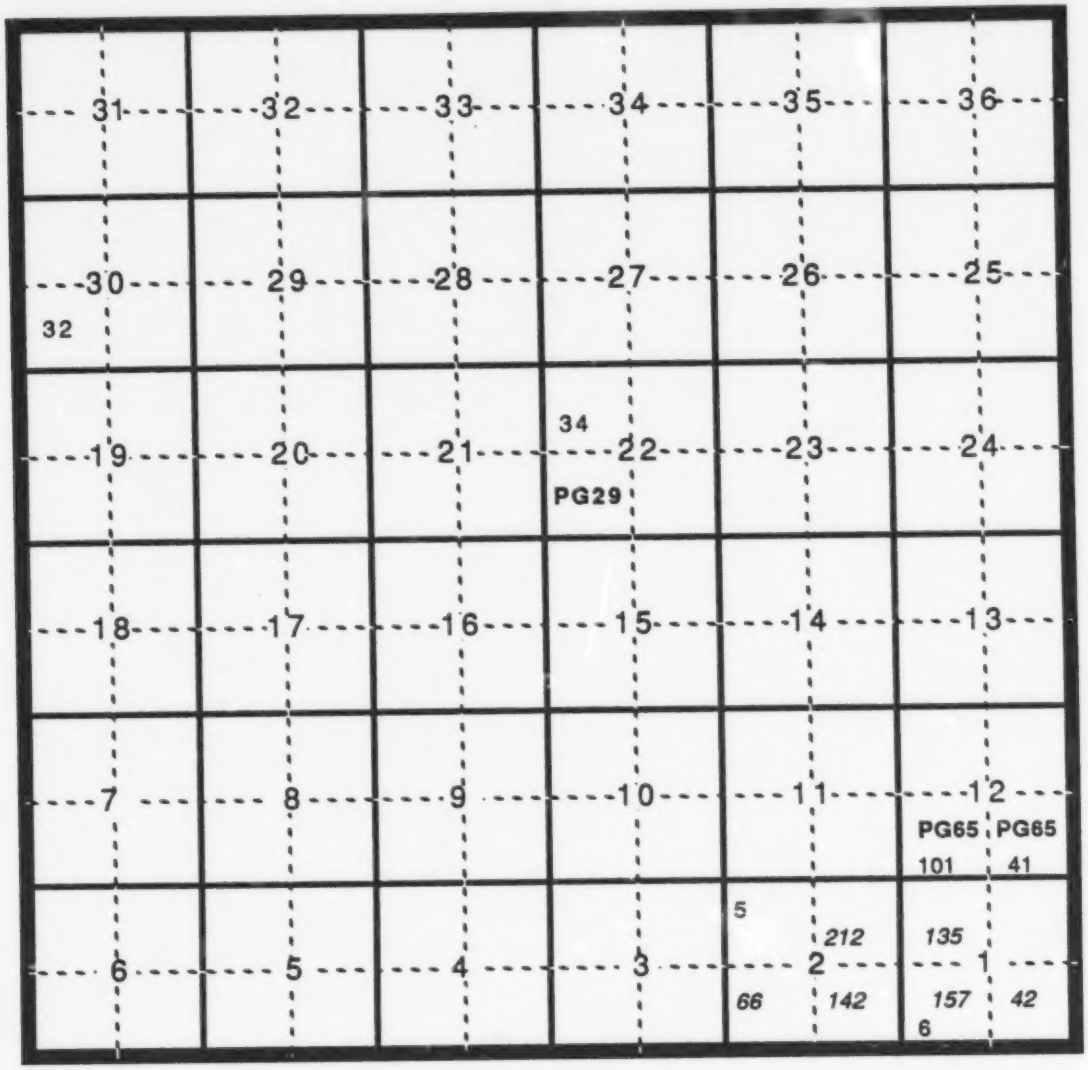
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of RUDY No. 284 Tp 31 Range 6 West of 3.



1971 Municipal Land Assessment

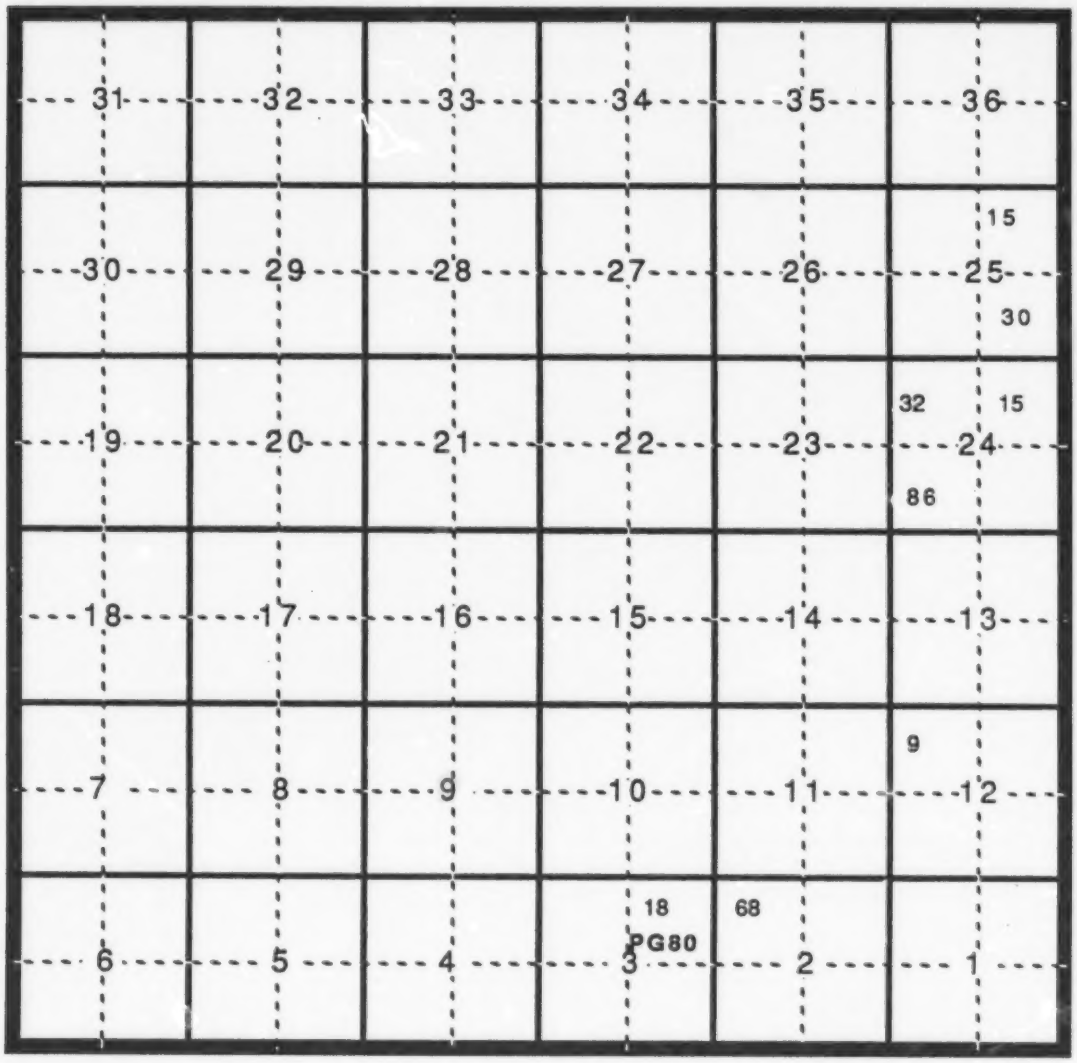
LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

RM of Rudy No. 284 Tp. 31 Range 7 West of 3.



1971 Municipal Land Assessment

LEGEND

75 = acres x salinity deduction / 10

75 = acres x solonetzic deduction / 10

PG50 = 50 acres designated as pasture grass
WS50 = 50 acres designated as waste slough

APPENDIX B

Water well maps prepared as part of this study

APPENDIX C

Depth, static level and chemical analyses of samples from water well survey

Appendix C. Depth, static level and chemical analyses of samples from waterwell survey

Farmer	Legal Location		Depth ft.	Static ft.	pH	E.C. dS/m	NO3-N mg/L	Na	Ca+Mg	K	Cl	HCO3	Cation	Salt*	SAR
									meq/L						
Jess Gary#	SW 04-05-28-3	W3	500	(+40)	8.6	2.75	<1	0.2	0.3	0.1	3.0	9.7	1	28	65
Follick G	NW05-07-27-4	W3	660	160	8.4	4.29	1	39.3	0.6	0.2	18.0	10.6	40	43	72
Langager L	NW15-08-27-4	W3	620	150	8.5	4.06	<1	33.0	0.5	0.2	13.5	11.7	34	41	66
Jackson D	NE13-19-27-4	W3	654	150	8.5	4.24	1	34.1	0.6	0.2	16.6	10.4	35	42	62
Glubis Ron#	NW04-31-27-4	W3	634	80	8.5	4.17	1	33.6	0.5	0.1	12.9	11.1	34	42	67
Lucki D	NW13-08-28-4	W3	580	120	8.7	3.35	<1	30.4	0.4	0.2	7.9	10.8	31	34	68
Cooper G.	NW13-21-29-4	W3	330	20	8.5	3.23	1	26.1	0.5	0.1	11.0	7.3	27	32	52
Sander I	NE01-04-30-4	W3	320	Flowing	8.2	3.03	1	24.3	0.6	0.1	8.0	7.6	25	30	44
Opdahl I	SE02-05-30-4	W3	450	20	8.4	3.37	1	27.6	0.9	0.2	7.5	7.1	29	34	41
Johnson H	NE07-06-30-4	W3	396	15	8.4	3.30	1	26.3	0.5	0.2	11.8	6.8	27	33	53
Torguson C	SW10-07-31-4	W3	390	Flowing	7.7	7.52	13	58.0	2.6	0.4	78.0	7.5	61	75	51
Harder Henry	NE16-18-31-4	W3	315	Flowing	8.1	4.02	<1	34.1	0.9	0.1	17.5	8.8	35	40	51
Torguson C&W	SW03-19-31-4	W3	217	Flowing	8.1	4.28	1	36.7	1.0	0.1	21.7	8.8	38	43	52
Kemmer H	SW03-30-31-4	W3	207	(+6)	7.5	3.16	<1	24.9	5.2	0.2	1.9	10.4	30	32	15
Knock Wayne	NE10-31-30-4	W3	56	35	7.4	3.22	19	15.9	16.4	0.3	2.2	7.3	33	32	6
Wilson R	SE08-16-32-4	W3	365	Flowing	7.2	2.63	<1	8.4	20.3	0.4	0.8	10.6	29	26	3
Glubis L +R	NE15-12-27-5	W3	570	165	8.5	4.51	1	43.6	0.6	0.2	18.5	10.1	44	45	80
Arthur A	NE16-20-27-5	W3	624	200	8.6	3.84	1	34.1	0.6	0.2	23.3	10.2	35	38	62
Follick Farms	NW14-21-27-5	W3	23	9	7.2	0.77	<1	0.3	7.6	0.6	0.3	7.8	9	8	0
Birch Farm	NE16-21-27-5	W3	610	187	8.2	3.92	1	32.5	0.6	0.2	22.5	10.3	33	39	59
Norrish D	SE01-27-27-5	W3	560	205	8.3	3.93	<1	32.0	0.6	0.2	19.8	10.4	33	39	58
Tastad R	SW02-29-27-5	W3	640	210	8.4	3.79	<1	29.9	0.6	0.2	21.8	10.5	31	38	55
Kallio M	NE16-20-28-5	W3	550	180	8.2	3.77	1	32.3	0.5	0.2	24.3	9.5	33	38	65
	SW12-24-28-5	W3	600	140	8.3	3.60	<1	29.9	0.4	0.2	20.1	10.2	31	36	67
Taylor C	SE02-04-28-5	W3	640	150	8.3	3.71	2	34.4	0.5	0.2	21.4	10.3	35	37	69
Simonson Brian	NE03-30-28-5	W3	18	14	7.3	1.12	8	1.9	10.1	0.6	1.0	7.7	13	11	1
Pederson E	NW01-14-29-5	W3	445	100	8.3	3.23	1	26.1	0.4	0.2	13.4	8.9	27	32	58
Overlid J	NW03-19-29-5	W3	66	59	7.4	2.79	4	17.6	10.3	0.3	1.1	8.4	28	28	8
Ringdol W	SE03-30-29-5	W3	500	100	8.2	3.61	1	29.0	0.8	0.2	17.9	7.4	30	36	46
Johnson L	SE16-02-30-5	W3	358	40	8.1	3.70	2	30.6	0.7	0.2	14.6	7.4	32	37	52
Haaland Neil	NW15-11-30-5	W3	?	?	7.8	3.58	1	28.0	3.6	0.2	13.1	7.9	32	36	21
Olson Clarence	SW07-14-30-5	W3	40	?	7.6	4.48	44	20.9	27.3	0.6	5.4	7.2	49	45	6
Taralson M	NE16-14-30-5	W3	40	22	7.3	3.67	26	18.5	19.7	0.4	4.0	8.9	39	37	6
Randall C.	SE04-27-6	W3	52	36	7.6	0.58	2	0.1	5.5	0.3	0.1	5.5	6	6	0
Stone Garry	NW03-07-27-6	W3	6	5	7.5	1.31	<1	1.1	13.2	0.2	0.2	6.2	15	13	0
Berenik David	SE02-11-27-6	W3	25	15	7.6	2.92	3	5.0	24.8	0.5	1.4	5.3	30	29	1
Norrish + Sons	SW03-25-27-6	W3	469	207	8.1	3.75	<1	30.9	0.8	0.3	19.6	10.1	32	38	49
Mclean R	SE09-26-27-6	W3	400	150	8.2	3.87	<1	31.1	0.9	0.2	20.6	8.9	32	39	46
Niska Bernard	SE09-30-27-6	W3	64	40	7.3	3.86	12	10.8	29.4	0.8	3.5	10.3	41	39	3
Simonson Nester	NE 16-06-28-6	W3	20	seepage	7.2	0.87	<1	0.6	8.1	0.0	0.1	8.8	9	9	0
Solnicka D.	NE 16-06-28-6	W3	20	<6	7.8	0.53	<1	0.6	4.4	0.5	0.1	4.0	6	5	0
Cutting Louis	NW 02-09-28-6	W3	<20	seepage	7.5	0.75	1	0.6	6.7	0.2	0.1	7.6	8	8	0
Solnicka Glen	NE16-09-28-6	W3	30	21	7.3	4.79	36	8.5	36.3	1.2	3.2	7.5	46	48	2
Mikulcik C.	NW12-14-28-6	W3	47	~30	7.3	5.37	79	11.6	37.6	1.3	3.5	10.3	51	54	3
Moir L	SE08-17-28-6	W3	115	85	7.3	2.44	<1	7.3	14.3	0.5	6.7	11.0	22	24	3
Hart Lester	NE14-18-28-6	W3	85	60	7.8	1.57	11	2.9	12.0	0.4	2.0	4.2	15	16	1
Riopka R.	SE08-32-28-6	W3	390	80	7.9	1.07	<1	6.4	2.7	0.2	0.3	5.6	9	11	6
Dosseiman Leo	NW13-34-28-6	W3	458	~180	7.9	5.11	<1	45.1	3.1	0.4	3.1	10.7	49	51	36
Thompson William	SW02-04-29-6	W3	18	13-15	7.2	5.56	53	21.0	34.5	1.3	2.4	9.2	57	56	5
Barber H.	SW04-04-29-6	W3	22	5-8	7.8	0.66	1	1.1	5.8	0.3	0.4	5.4	7	7	1
Zlatnik Ken	NW05-04-29-6	W3	40	~20	7.0	6.14	71	25.3	34.1	1.4	7.7	11.1	61	61	6
Glenside Village	05-05-29-6	W3	400	?	7.8	1.36	1	9.7	2.3	0.2	0.5	6.8	12	14	9
Tomecek W.	SE11-05-29-6	W3	340	~60	7.6	2.06	<1	15.6	4.4	0.3	0.9	8.3	20	21	11
Macdonald G.K.	SE01-07-29-6	W3	340	50	7.5	2.67	<1	17.4	9.3	0.4	1.0	11.9	27	27	8
McCullough William	SW05-09-29-6	W3	365	110	7.9	3.94	<1	33.0	2.7	0.2	3.1	11.0	36	39	28
Rysavy Donald	SE08-10-29-6	W3	36	6	7.8	2.38	16	8.7	14.7	0.5	2.9	6.2	24	24	3
Gifford R. B.	SE11-10-29-6	W3	443	80	8.2	3.95	<1	31.3	1.5	0.3	17.6	8.4	33	40	36
Gifford R. B.	SE11-10-29-6	W3	50	35	7.6	3.15	4	18.3	11.2	0.4	9.0	8.5	30	32	8
Simonson Ken	NW14-12-29-6	W3	50	33	7.3	2.48	<1	12.0	12.7	0.5	1.0	4.8	25	25	5
Martens Victor	SW01-15-29-6	W3	29	12	7.4	2.00	1	4.6	14.9	0.2	4.2	8.4	20	20	2
McCullough William	NW04-17-29-6	W3	50-60	~40	7.6	2.16	<1	2.4	22.2	0.5	0.5	7.1	25	22	1
Simonson David	NW14-19-29-6	W3	140?	10?	7.8	4.16	<1	32.8	7.1	0.4	3.6	9.7	40	42	17
McPherson J.R.	SE12-21-29-6	W3	275	~12	8.2	3.99	<1	34.0	1.3	0.2	14.1	7.8	36	40	42
McPherson Russ	SE13-21-29-6	W3	320	23	8.1	3.91	<1	34.3	1.3	0.2	15.1	7.9	36	39	43
Martens Peter	NE04-28-29-6	W3	235	50	8.9	4.31	<1	37.6	1.0	0.3	16.1	6.1	39	43	53
Tomecek Bob	SE01-32-29-6	W3	258	3-5	8.2	4.07	<1	35.0	1.4	0.3	14.2	7.3	37	41	42
Omnes Thelma	SE02-34-29-6	W3	317	?	7.3	3.94	<1	33.6	2.0	0.2	15.0	9.2	36	39	34

Appendix C. Depth, static level and chemical analyses of samples from waterwell survey

Farmer	Legal Location		Depth ft.	Static ft.	pH	E.C. dS/m	NO3-N mg/L	Na	Ca+Mg	K	Cl	HCO3	Cation	Salt*	SAR
									----------meq/L----------						
Morken Gorden	NE09-05-30-6	W3	195	Flowing	7.7	3.56	<1	27.1	4.1	0.3	13.7	8.2	32	36	19
Eliason Alan	SE08-09-30-6	W3	22	14	7.5	1.14	10	1.6	10.5	0.2	0.7	5.5	12	11	1
Eliason Jerry	SW12-11-30-6	W3	65	38	8.2	3.48	<1	30.7	1.3	0.3	9.9	7.6	32	35	38
Eliason John	NW01-15-30-6	W3	35	30	7.6	1.04	11	2.6	7.8	0.5	0.9	8.7	11	10	1
Broderick marsh	SW3-18-30-6	W3	?	Flowing	7.4	3.70	2	27.4	5.3	0.3	9.6	7.8	33	37	17
Dyck H. P.	NE 16-24-30-6	W3	14	10	7.9	0.97	33	1.4	8.1	0.4	0.8	8.0	10	10	1
Peters Edward	NE16-25-30-6	W3	363	50	7.7	11.16	25	102.7	5.8	0.5	149.9	2.8	109	112	60
Abrahams Ed	NE13-34-30-6	W3	280	60	7.9	10.67	25	96.1	4.7	0.4	150.5	3.0	101	107	63
Burlingame Wayne	NW11-03-31-6	W3	40	15	7.6	2.38	<1	7.7	18.3	1.4	1.7	8.1	27	24	3
Patkau Allen	NE01-12-31-6	W3	31	14	8.0	3.25	25	18.9	10.9	0.6	25.5	7.8	30	33	8
Patkau Allen	NE01-12-31-6	W3	260	10	8.0	7.87	16	72.2	2.8	0.3	113.2	4.4	75	79	61
Ebbert Walter	NW14-20-31-6	W3	19	16	7.6	0.62	<1	0.7	5.6	0.2	0.2	5.2	7	6	0
Ebbert Walter	NE05-32-31-6	W3	25	20	7.6	0.57	<1	1.4	4.1	0.1	0.3	5.1	6	6	1
Abrahmson J (old)	SW16-32-31-6	W3	12	8	7.6	0.62	<1	2.7	3.6	0.1	0.2	7.2	6	6	2
Abrahmson Jesse	SW16-32-31-6	W3	12	8	7.7	0.83	1	2.1	6.7	0.1	0.3	7.8	9	8	1
PFRA	NE01-12-27-7	W3	?	?	8.6	3.48	<1	30.2	0.9	0.3	2.5	11.1	31	35	45
Hauberg Norman	NW14-12-27-7	W3	60	20	7.3	1.91	<1	2.1	19.9	0.3	0.2	6.6	22	19	1
Carlson Arnold	SE03-13-27-7	W3	74	18	7.4	7.61	54	48.7	28.4	1.1	9.8	7.6	78	76	13
Carlson Arnold	SE04-13-27-7	W3	Spring	Flowing	7.7	1.91	<1	5.8	13.0	0.3	0.3	6.6	19	19	2
Hauberg Stan	SE09-26-27-7	W3	193	50	7.9	3.21	<1	21.9	7.9	0.4	1.7	11.1	30	32	11
Vester Farms	NE14-33-27-7	W3	20	18	7.2	3.18	4	5.6	29.3	0.5	1.3	8.3	35	32	2
Bull Bill	NW01-34-27-7	W3	160	25	7.4	0.80	<1	1.4	7.1	0.2	0.2	5.9	9	8	1
Peterman Larry	NE16-35-27-7	W3	37	7	7.8	0.52	1	0.5	4.8	0.2	0.1	4.0	6	5	0
Johnson Gordon	SW04-02-28-7	W3	52	~20	7.3	4.08	2	13.7	26.3	0.7	5.9	12.2	41	41	4
Johnson Orvall	NE16-05-28-7	W3	22	18	7.6	1.82	2	3.4	13.1	0.3	6.3	6.3	17	18	1
Britnell Bernie	SW04-09-28-7	W3	52	16-20	7.1	5.35	13	21.3	37.1	0.9	6.3	6.8	59	54	5
Rependa John	NE15-11-28-7	W3	18	8	6.8	0.65	8	0.2	7.4	0.2	0.1	4.9	8	7	0
Pederson Roger	NW13-17-28-7	W3	24	10-15	7.5	4.15	<1	13.8	27.0	0.8	1.2	7.0	42	42	4
Pederson Gary	SW13-20-28-7	W3	30	24	7.3	2.77	17	3.3	25.4	0.9	2.4	6.7	30	28	1
Tomasiewicz Stan	NW05-28-28-7	W3	27	~20	6.4	2.49	18	5.7	21.9	0.4	2.3	1.7	28	25	2
Tomasiewicz Leo	SW08-30-28-7	W3	28	11	7.5	1.88	<1	3.4	15.3	0.5	0.6	6.9	19	19	1
Matlock Dan	SW04-32-28-7	W3	29	10	7.5	4.42	8	12.4	33.0	1.0	1.9	7.2	46	44	3
Matlock Dan	SW04-32-28-7	W3	209	30	8.2	4.40	<1	35.2	4.8	0.4	1.7	9.0	40	44	23
Ripka A.	NE14-32-28-7	W3	16	8	7.6	3.14	124	0.7	32.8	0.2	4.8	5.5	34	31	0
Vaxick Wayne	SW02-36-28-7	W3	~20	~14	7.7	3.35	31	12.1	19.4	0.4	2.8	7.2	32	34	4
Rysavy Ray	SE16-02-29-7	W3	98	24	7.5	6.59	21	46.7	20.8	0.6	5.1	7.2	68	66	15
Balleck John#	SW02-04-29-7	W3	12	seepage	7.3	0.89	1	0.8	8.5	0.4	0.5	7.5	10	9	0
Peardon Daryl	NW05-05-29-7	W3	40	10	8.1	1.16	1	0.8	10.4	0.2	1.1	6.9	11	12	0
Osvirk Luke#	NE 16-09-29-7	W3	94	68	7.4	4.35	1	29.5	13.5	0.2	2.7	11.0	43	44	11
HDN Farm	SE09-13-29-7	W3	28	2-28	7.9	2.57	9	11.0	12.2	0.4	1.0	5.8	24	26	5
SWP Broderick	SE13-15-29-7	W3	28	2.5	7.4	5.71	<1	33.0	22.4	0.9	6.5	8.5	56	57	10
Follick B.	NE14-18-29-7	W3	21	15	7.6	0.89	8	1.2	7.4	0.2	0.5	6.0	9	9	1
Barrich Farm	SW04-19-29-7	W3	293	120	8.0	3.78	<1	33.1	3.2	0.3	11.4	8.0	37	38	26
N&H Farm	NW12-23-29-7	W3	119	14	7.5	2.59	1	12.7	13.1	1.4	2.0		27	26	5
Kasper John	NW13-35-29-7	W3	240	90	8.1	4.68	1	42.0	1.8	0.3	5.9	7.5	44	47	44
Duncan Bill	NW13-01-30-7	W3	27	13	8.1	0.56	2	1.2	4.6	0.1	0.1	5.2	6	6	1
Kubashek Tony	NW13-03-30-7	W3	22	14	7.7	1.00	19	2.3	8.3	0.1	0.9	7.0	11	10	1
Walberg Dennis#	NE08-21-30-7	W3	32	16	7.4	0.59	1	1.6	4.6	0.1	0.1	5.4	6	6	1
Buchmann Karl	NE13-22-30-7	W3	72	20	7.7	1.01	17	1.7	8.8	0.3	1.0	7.4	11	10	1
Carlson Grant	NE16-22-30-7	W3	50	10	7.3	3.16	<1	1.6	33.7	0.6	3.7	9.4	36	32	0
Larson Russell	NW05-24-30-7	W3	245	90	8.2	5.73	7	52.9	1.5	0.3	56.4	6.1	55	57	61
Carlson Kieth	NW04-27-30-7	W3	40	6	7.4	1.59	1	2.9	15.9	0.3	0.7	8.0	19	16	1
Larson H.N.	NE03-30-30-7	W3	65	10	7.7	5.55	86	9.7	50.5	0.2	20.8	5.5	60	56	2
Burlingame Wayne	NW15-32-30-7	W3	40	22	7.7	1.76	4	2.3	14.3	0.3	1.0	5.6	17	18	1
Verwimp Paul	SE16-33-30-7	W3	14	3	7.6	2.63	12	5.9	20.4	0.4	1.3	6.5	27	26	2
Koster Walter	NE15-36-30-7	W3	30	6	7.5	3.10	12	6.1	19.6	0.4	1.2	7.7	26	31	2
Koster Walter	NE15-36-30-7	W3	300	85	8.1	10.08	23	92.5	4.5	0.4	156.1	2.7	97	101	62
Dahl Ken	NE16-04-31-7	W3	30	28	7.7	1.93	90	2.4	15.3	0.3	3.2	4.6	18	19	1
Dahl Ken (house)	NE16-04-31-7	W3	30	28	7.6	0.70	5	1.1	6.2	0.2	0.4	4.9	8	7	1
Robson Sonja	SW13-08-31-7	W3	32	16	7.9	1.25	14	3.2	9.2	0.2	0.8	6.1	13	13	2
Fuglerud Dennis	NE04-13-31-7	W3	13	6	7.7	0.58	2	0.4	5.5	0.1	0.3	5.1	6	6	0
Derdall Ed	NW04-14-31-7	W3	20	?	7.8	0.57	2	0.5	5.4	0.1	0.2	4.7	6	6	0
Dahl Randy	SE12-15-31-7	W3	24	20	7.9	0.48	1	1.0	3.7	0.2	0.3	3.5	5	5	1
Henricks Harvey	SE03-17-31-7	W3	30	24	7.7	2.51	23	3.8	20.0	1.8	3.5	6.5	26	25	1
Dahl Lloyd	SE01-21-31-7	W3	22	20	7.8	0.94	<1	1.3	8.8	0.2	0.3	3.6	10	9	1
Dahl Manfred	NW05-23-31-7	W3	25	21	7.8	0.69	1	0.8	6.2	0.1	0.3	4.5	7	5	1

Appendix C. Depth, static level and chemical analyses of samples from waterwell survey

Farmer	Legal Location		Depth ft.	Static ft.	pH	E.C. dS/m	NO3-N mg/L	Na	Ca+Mg	K	Cl	HCO3	Cation	Salt*	SAR
									meq/L						
Yahn S	SW04-28-27-8	W3	110	63	7.1	1.43	1	0.9	16.4	0.4	0.5	7.0	18	14	0
Murray Albert	SE16-32-27-8	W3	46	30	7.0	6.04	143	15.1	51.4	1.1	8.8	9.0	68	60	3
Torvik C	NW04-33-27-8	W3	91	?	7.3	1.25	1	1.7	12.7	0.4	0.1	6.5	15	13	1
Harvey Clint	SE04-04-28-8	W3	48	37	7.3	2.49	9	2.0	27.4	0.4	1.2	5.1	30	25	1
Nadeau	NE01-09-29-8	W3	244	60	7.5	2.97	<1	15.7	9.6	1.1	0.1	9.0	26	30	7
Vavra John	NW16-09-29-8	W3	40	20	7.8	1.45	3	1.2	9.4	0.7	0.6	11.5	11	15	1
Moore T.E.	NW13-14-29-8	W3	170	130	7.7	1.05	<1	4.4	5.9	0.2	0.2	7.3	11	11	3
Vacant	NW15-14-29-8	W3	18	15	7.8	0.73	<1	1.7	4.9	0.2	0.5	5.1	7	7	1
LARSON E.	NW22-29-8	W3			8.0	1.00		4.7	6.5	0.2	0.1	6.9	11	10	3
Larson R.	NE14-23-29-8	W3	10	5	7.9	0.72	1	1.0	5.6	0.2	0.2	4.8	7	7	1
Larson R.	NW14-23-29-8	W3	30	11	7.8	0.75	3	0.9	5.8	0.2	0.3	4.9	7	8	1
Jacobson Juhl	SW12-25-29-8	W3	30	15	7.8	1.15	11	2.0	8.4	0.2	1.0	5.3	11	12	1
Burke Ralph	SE09-26-29-8	W3	18	8	7.8	1.00	1	2.3	6.8	0.2	0.5	4.0	9	10	1
Haug Oswald	SW13-32-29-8	W3	20	14	7.6	0.61	4		6.4	0.2	0.3	4.5	7	6	0
Jacobson Juhl	SW04-36-29-8	W3	30	15	7.9	0.63	<1	0.7	5.1	0.2	0.3	4.5	6	6	0
Hettrick Harvey	NE16-34-29-8	W3	24	12	7.6	1.60	4	3.0	14.1	0.3	0.7	6.0	17	16	1
McDonough Marwood	SW01-01-30-8	W3	14	12	7.9	0.70	<1	1.6	5.4	0.1	0.2	4.0	7	7	1
Henricks Harold	NW16-02-30-8	W3	24	16	7.6	0.63	1	0.9	5.2	0.1	0.3	5.7	6	6	1
Komst John	SE01-10-30-8	W3	15	10	7.8	0.50	<1	1.1	3.6	0.1	0.3	3.8	5	5	1
Skilling: tad E.#	SW05-18-30-8	W3	14	11	7.5	0.54	5	0.3	5.2	0.1	0.1	4.0	6	5	0
Silverthorn Don	SE01-30-30-8	W3	33	20	7.6	0.54	1	0.8	4.8	0.2	0.1	4.4	6	5	0
	SE04-05-31-8	W3	10	8	7.8	2.44	3	7.0	18.6	0.6	1.3	5.4	26	24	2
Johnston J. T.#	NW16-34-28-10	W3	32	28	7.4	3.98	3	7.0	41.4	0.3	3.5	6.2	49	40	2

These samples were obtained at the Outlook public meeting March 25, 1988.
* Salt = E.C. * 10

APPENDIX D

Chemical analyes of soil samples from hydraulic rotary drilling

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-101	0-2.5	7.7	3.38	5.91	611	691	11	30	26.6	43.2	0.3	0.8	70	59	6
	2.5-5.0	7.7	1.94	3.28	285	414	12	24	12.4	25.9	0.3	0.7	39	33	3
	5.0-7.5	7.8	1.70	2.80	169	447	9	15	7.3	27.9	0.2	0.4	36	28	2
	7.5-10.0	8.0	1.77	2.73	396	198	9	29	17.2	12.4	0.2	0.8	30	27	7
	10.0-12.5	8.1	1.23	1.81	264	102	26	13	11.5	6.4	0.7	0.4	19	18	6
	12.5-15.0	7.1	2.37	3.60	536	273	7	30	23.3	17.1	0.2	0.8	41	36	8
	15.0-17.5	7.6	2.55	3.43	349	419	6	20	15.2	26.2	0.2	0.6	42	34	4
	17.5-20	7.6	2.35	3.80	436	397	5	25	19.0	24.8	0.1	0.7	44	38	5
	20-25	7.6	2.83	4.60	488	539	7	26	21.2	33.7	0.2	0.7	55	46	5
	25-30	8.4	2.29	3.62	332	475	5	22	14.4	29.7	0.1	0.6	44	36	4
	30-35	7.2	2.45	3.91	382	483	5	29	16.6	30.2	0.1	0.8	47	39	4
	35-40	7.3	1.96	2.92	336	286	7	20	14.6	17.9	0.2	0.6	33	29	5
	40-45	8.7	1.18	1.30	217	21	9	6	9.4	1.3	0.2	0.2	11	13	12
	45-50	8.7	1.33	1.53	256	20	9	7	11.1	1.3	0.2	0.2	13	15	14
	50-55	8.6	1.58	1.80	309	21	18	8	13.4	1.3	0.5	0.2	15	18	17
	55-60	8.0	1.99	2.57	462	35	8	17	20.1	2.2	0.2	0.5	22	26	19
	60-65	7.4	2.47	3.02	539	57	10	19	23.4	3.6	0.3	0.5	27	30	18
	65-70	7.5	2.48	3.04	541	54	10	18	23.5	3.4	0.3	0.5	27	30	18
	70-75	8.0	2.29	2.68	478	29	8	16	20.8	1.8	0.2	0.5	23	27	22
	75-80	7.7	2.35	2.90	519	41	11	28	22.6	2.6	0.3	0.8	25	29	20
	80-85	8.0	2.13	2.53	442	26	13	24	19.2	1.6	0.3	0.7	21	25	21
	85-90	7.9	1.97	2.22	381	35	11	26	16.6	2.2	0.3	0.7	19	22	16
	90-95	8.0	2.27	2.87	508	32	18	30	22.1	2.0	0.5	0.8	25	29	22
	95-100	7.9	2.26	2.74	474	41	17	28	20.6	2.6	0.4	0.8	24	27	18
	100-105	7.8	2.19	2.68	476	25	9	54	20.7	1.6	0.2	1.5	22	27	23
	105-110	7.4	2.48	3.28	591	48	13	31	25.7	3.0	0.3	0.9	29	33	21
	110-115	7.6	2.48	3.07	540	48	11	29	23.5	3.0	0.3	0.8	27	31	19
	115-120	7.9	2.12	2.42	419	32	8	32	18.2	2.0	0.2	0.9	20	24	18
	120-125	7.4	1.96	2.65	467	28	8	47	20.3	1.8	0.2	1.3	22	27	22
	125-130	8.5	2.15	2.68	473	20	6	52	20.6	1.3	0.2	1.5	22	27	26
	130-135	8.4	2.53	2.99	549	27	9	43	23.9	1.7	0.2	1.2	26	30	26
	135-140	7.9	2.93	3.52	670	40	10	49	29.1	2.5	0.3	1.4	32	35	26
	140-145	8.4	3.31	3.87	726	33	10	65	31.6	2.1	0.3	1.8	34	39	31
	145-150	7.6	3.87	4.77	875	63	15	57	38.0	3.9	0.4	1.6	42	48	27
	150-155	7.1	4.21	5.43	1023	103	20	66	44.5	6.4	0.5	1.9	51	54	25
	155-160	7.6	4.03	5.04	924	73	17	66	40.2	4.6	0.4	1.9	45	50	27
	160-165	7.6	4.21	5.41	1014	92	19	79	44.1	5.8	0.5	2.2	50	54	26
	165-170	7.6	3.97	5.47	1010	102	19	80	43.9	6.4	0.5	2.3	51	55	25
	170-175	7.6	4.16	5.20	972	98	17	70	42.3	6.1	0.4	2.0	49	52	24
	175-180	8.4	3.25	3.75	662	42	12	61	28.8	2.6	0.3	1.7	32	38	25
	180-185	8.1	2.86	3.28	601	26	9	60	26.1	1.6	0.2	1.7	28	33	29
	185-190	7.7	2.78	3.15	568	33	8	59	24.7	2.1	0.2	1.7	27	32	24
	190-195	7.5	3.50	4.00	727	68	11	62	31.6	4.3	0.3	1.7	36	40	22
	195-200	7.3	3.21	3.66	682	55	10	49	29.7	3.4	0.3	1.4	33	37	23
	200-205	6.8	3.80	4.63	857	94	15	47	37.3	5.9	0.4	1.3	44	46	22
	205-210	6.7	3.44	4.11	745	83	14	67	32.4	5.2	0.4	1.9	38	41	20
	210-215														
	215-220	7.1	2.70	3.32	609	41	11	103	26.5	2.6	0.3	2.9	29	33	23
	220-225	6.4	3.68	4.95	928	137	20	120	40.3	8.6	0.5	3.4	49	50	20
	225-230	6.2	3.73	4.92	979	137	18	94	42.6	8.6	0.5	2.6	52	49	21
	230-235	6.4	3.51	4.53	842	96	18	90	36.6	6.0	0.5	2.5	43	45	21
	235-240	6.4	3.85	4.84	988	119	23	60	43.0	7.4	0.6	1.7	51	48	22
	240-245	7.1	3.42	4.44	794	70	18	70	34.5	4.4	0.5	2.0	39	44	23
	245-250	6.7	4.06	5.36	1039	131	25	76	45.2	8.2	0.6	2.1	54	54	22
	250-255	6.8	3.94	5.06	1017	115	24	72	44.2	7.2	0.6	2.0	52	51	23
	255-260	7.2	3.85	4.80	916	76	16	95	39.8	4.8	0.4	2.7	45	48	26
	260-265	7.9	3.39	4.05	736	30	12	70	32.0	1.9	0.3	2.0	34	41	33
	265-270	7.5	3.42	4.37	774	49	15	91	33.7	3.1	0.4	2.6	37	44	27
	270-275	7.6	3.10	3.79	662	32	19	79	28.8	2.0	0.5	2.2	31	38	29
	275-280	7.5	3.35	4.22	747	48	22	96	32.5	3.0	0.6	2.7	36	42	27
	280-285	7.4	3.14	3.91	691	47	21	78	30.0	2.9	0.5	2.2	34	39	25
	285-290	7.5	3.06	3.52	648	36	21	74	28.2	2.3	0.5	2.1	31	35	27
	290-295	7.5	2.89	3.56	610	38	20	71	26.5	2.4	0.5	2.0	29	36	24
	295-300	7.8	2.87	3.47	584	24	18	83	25.4	1.5	0.5	2.3	27	35	29
	300-305	7.7	2.89	3.54	612	31	19	80	26.6	1.9	0.5	2.3	29	35	27
	305-310	7.4	3.54	4.11	748	55	23	69	32.5	3.4	0.6	1.9	37	41	25
	310-315	7.8	3.74	4.70	830	47	16	117	36.1	2.9	0.4	3.3	39	47	30
	315-320	8.1	3.32	4.33	781	46	13	136	34.0	2.9	0.3	3.8	37	43	28
	320-325	7.4	3.92	5.22	945	73	14	156	41.1	4.6	0.4	4.4	46	52	27
	325-330	7.4	4.06	5.34	1004	77	16	147	43.7	4.8	0.4	4.1	49	53	28
	330-335	7.2	4.03	5.09	905	83	27	114	39.3	5.2	0.7	3.2	45	51	24
	335-340	7.5	3.85	4.54	844	59	16	117	36.7	3.7	0.4	3.3	41	45	27

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						--------mg/L--------				--------meq/L-------			--meq/L--		
87-OK-101	340-345	7.3	4.01	5.15	961	87	32	133	41.8	5.4	0.8	3.7	48	52	25
	345-350	7.3	4.14	4.97	1011	90	32	105	44.0	5.6	0.8	3.0	50	50	26
	350-355	7.5	3.65	4.62	897	55	22	108	39.0	3.4	0.6	3.0	43	46	30
	355-360	7.2	3.86	4.84	909	85	26	86	39.5	5.3	0.7	2.4	46	48	24
	360-365	7.0	4.44	5.34	1042	122	32	79	45.3	7.6	0.8	2.2	54	53	23
	365-370	7.2	4.31	5.45	1051	117	31	87	45.7	7.3	0.8	2.5	54	55	24
	370-375	7.4	4.27	5.38	969	83	24	113	42.1	5.2	0.6	3.2	48	54	26
	375-380	7.4	4.21	5.13	957	72	26	105	41.6	4.5	0.7	3.0	47	51	28
	380-385	8.1	3.26	3.91	698	26	16	91	30.3	1.6	0.4	2.6	32	39	34
	385-390	7.9	3.53	3.94	725	31	18	111	31.5	1.9	0.5	3.1	34	39	32
	390-395	7.6	3.45	3.96	725	35	20	110	31.5	2.2	0.5	3.1	34	40	30
	395-400	7.7	3.71	4.24	793	38	20	110	34.5	2.4	0.5	3.1	37	42	32
	400-405	7.6	3.93	4.68	882	55	23	114	38.3	3.4	0.6	3.2	42	47	29
	405-410	7.5	3.54	4.14	780	38	20	109	33.9	2.4	0.5	3.1	37	41	31
	410-415	7.5	3.50	4.24	794	46	20	114	34.5	2.9	0.5	3.2	38	42	29
	415-420	7.6	3.97	4.69	864	58	22	115	37.6	3.6	0.6	3.2	42	47	28
	420-425	7.6	3.77	4.55	850	51	20	125	37.0	3.2	0.5	3.5	41	46	29
	425-430	7.7	3.32	3.90	745	30	18	129	32.4	1.9	0.5	3.6	35	39	33
	430-435	7.3	4.50	5.63	1073	87	26	142	46.7	5.4	0.7	4.0	53	56	28
	435-440	7.3	4.59	5.56	1055	100	26	145	45.9	6.3	0.7	4.1	53	56	26
	440-445	7.2	4.33	5.29	973	115	30	124	42.3	7.2	0.8	3.5	50	53	22
	445-450	7.3	3.74	4.55	832	62	23	120	36.2	3.9	0.6	3.4	41	46	26
	450-455	7.7	3.85	4.89	880	74	23	180	38.3	4.6	0.6	5.1	43	49	25
	455-460	7.4	4.32	5.54	1007	126	29	134	43.8	7.9	0.7	3.8	52	55	22
	460-465	8.1	3.04	4.18	752	40	15	301	32.7	2.5	0.4	8.5	36	42	29
	465-470	7.8	3.21	4.36	792	36	17	277	34.4	2.3	0.4	7.8	37	44	32
	470-475	7.6	3.52	4.84	895	58	19	274	38.9	3.6	0.5	7.7	43	48	29
	475-480	7.5	3.83	5.44	990	82	24	308	43.0	5.1	0.6	8.7	49	54	27
	480-485	7.3	3.76	5.23	957	81	22	237	41.6	5.1	0.6	6.7	47	52	26
	485-490	7.3	4.01	5.54	1037	90	22	242	45.1	5.6	0.6	6.8	51	55	27
	490-495	7.7	3.22	4.14	750	34	16	218	32.6	2.1	0.4	6.1	35	41	32
	495-500	7.9	2.96	3.56	658	18	13	186	28.6	1.1	0.3	5.2	30	36	38
	500-505	8.6	1.71	1.96	362	3	11	358	15.7	0.2	0.3	10.1	16	20	51
	505-510	8.4	2.14	2.81	509	10	8	545	22.1	0.6	0.2	15.4	23	28	40
	510-515	8.7	1.98	2.48	423	3	8	597	18.4	0.2	0.2	16.8	19	25	60
	515-520	8.5	2.23	2.75	478	11	7	487	20.8	0.7	0.2	13.7	22	28	35
	520-525	8.2	3.00	3.81	671	26	14	281	29.2	1.6	0.4	7.9	31	38	32
	525-530	8.5	2.59	3.10	555	16	11	229	24.1	1.0	0.3	6.5	25	31	34
	530-535	7.9	3.12	3.97	709	36	14	238	30.8	2.3	0.4	6.7	33	40	29
	535-540	8.4	2.38	2.58	442	9	9	215	19.2	0.6	0.2	6.1	20	26	36
	540-545	8.6	1.86	1.65	292	3	13	290	12.7	0.2	0.3	8.2	13	17	41
	545-550	8.6	1.78	1.80	316	3	10	330	13.7	0.2	0.3	9.3	14	18	45
	550-555	8.6	2.14	2.28	401	15	3	424	17.4	0.9	0.1	11.9	18	23	25
	555-560	9.0	1.78	1.99	345	8	9	514	15.0	0.5	0.2	14.5	16	20	30
	560-565	8.7	1.87	2.36	418	6	3	439	18.2	0.4	0.1	12.4	19	24	42
	565-570	8.6	2.34	2.91	492	6	4	567	21.4	0.4	0.1	16.0	22	29	49
	570-575	8.8	2.24	2.34	406	12	4	405	17.7	0.8	0.1	11.4	19	23	29
	575-580	8.6	2.43	2.74	480	14	4	341	20.9	0.9	0.1	9.6	22	27	32
	580-585	8.5	1.98	2.15	385	11	3	312	16.7	0.7	0.1	8.8	18	22	29
	585-590	8.4	2.06	2.15	382	16	4	358	16.6	1.0	0.1	10.1	18	22	23
	590-595	8.8	1.84	1.87	336	3	3	273	14.6	0.2	0.1	7.7	15	19	48
	595-600	8.6	1.99	2.01	356	13	3	251	15.5	0.8	0.1	7.1	16	20	24
	600-605	8.4	2.31	2.29	389	16	4	176	16.9	1.0	0.1	5.0	18	23	24
	605-610	8.3	2.31	2.45	432	10	4	162	18.8	0.6	0.1	4.6	20	25	34
87-OK-102	0-2.5														
	2.5-5.0														
	5.0-7.5														
	7.5-10.0														
	10.0-12.5														
	12.5-15.0														
	15.0-17.5														
	17.5-20	8.0	0.76	0.98	28	122	24	8	1.2	7.6	0.6	0.2	9	10	1
	20-25	8.3	0.61	0.75	17	90	21	6	0.7	5.6	0.5	0.2	7	8	0
	25-30	8.4	0.54	0.66	17	74	20	6	0.7	4.6	0.5	0.2	6	7	0
	30-35	8.3	0.68	0.83	22	100	22	7	1.0	6.3	0.6	0.2	8	8	1
	35-40	8.3	0.63	0.82	26	92	20	5	1.1	5.8	0.5	0.1	7	8	1
	40-45	8.4	0.56	0.70	30	65	19	7	1.3	4.1	0.5	0.2	6	7	1
	45-50	8.3	0.71	0.88	39	90	19	5	1.7	5.6	0.5	0.1	6	9	1
	50-55	8.3	0.67	0.83	45	76	19	6	2.0	4.8	0.5	0.2	7	8	1
	55-60	8.2	0.73	0.92	53	84	19	6	2.3	5.3	0.5	0.2	6	9	1
	60-65	8.1	1.11	1.28	79	133	22	5	3.4	8.3	0.6	0.1	12	13	2

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-102	65-70	8.1	1.22	1.35	88	138	23	5	3.8	8.6	0.6	0.1	13	14	2
	70-75	8.1	1.28	1.43	98	148	25	4	4.3	9.3	0.6	0.1	14	14	2
	75-80	8.1	1.32	1.55	107	145	25	5	4.7	9.1	0.6	0.1	14	16	2
	80-85	8.1	1.20	1.34	108	120	24	8	4.7	7.5	0.6	0.2	13	13	2
	85-90	8.1	1.35	1.58	119	142	26	6	5.2	8.9	0.7	0.2	15	16	2
	90-95	8.0	1.49	1.81	139	160	26	6	6.0	10.0	0.7	0.2	17	18	3
	95-100	8.0	1.48	1.82	150	153	26	7	6.5	9.6	0.7	0.2	17	18	3
	100-105	8.1	1.31	1.60	149	114	25	10	6.5	7.1	0.6	0.3	14	16	3
	105-110	8.0	1.59	1.98	182	153	29	8	7.9	9.6	0.7	0.2	18	20	4
	110-115	8.0	1.47	1.85	178	129	24	7	7.7	8.1	0.6	0.2	16	19	4
	115-120	8.1	1.35	1.68	181	97	26	9	7.9	6.1	0.7	0.3	15	17	5
	120-125	8.8	1.07	1.26	181	34	28	12	7.9	2.1	0.7	0.3	11	13	8
	125-130	8.1	2.01	2.39	263	148	21	16	11.4	9.3	0.5	0.5	21	24	5
	130-135	8.5	1.60	1.83	237	71	20	7	10.3	4.4	0.5	0.2	15	18	7
	135-140	8.5	1.57	1.83	233	75	20	9	10.1	4.7	0.5	0.3	15	18	7
	140-145	8.0	2.16	2.89	283	221	27	20	12.3	13.8	0.7	0.6	27	29	5
	145-150	8.0	2.11	2.42	240	162	25	27	10.4	10.1	0.6	0.8	21	24	5
	150-155	8.0	2.13	2.51	272	159	28	34	11.8	9.9	0.7	1.0	22	25	5
	155-160	8.2	1.79	2.01	232	96	19	34	10.1	6.0	0.5	1.0	17	20	6
	160-165	8.0	2.07	2.52	290	144	23	33	12.6	9.0	0.6	0.9	22	25	6
	165-170	8.1	2.28	2.72	363	133	24	47	15.8	8.3	0.6	1.3	25	27	8
	170-175														
	175-180	8.7	1.37	1.66	261	29	12	7	11.3	1.8	0.3	0.2	13	17	12
	180-185	7.7	2.77	3.61	493	196	23	36	21.4	12.3	0.6	1.0	34	36	9
	185-190	7.7	2.95	3.91	538	218	24	42	23.4	13.6	0.6	1.2	38	39	9
	190-195	8.4	1.63	2.01	318	36	14	10	13.8	2.3	0.4	0.3	16	20	13
	195-200	8.3	1.48	1.89	308	28	16	15	13.4	1.8	0.4	0.4	16	19	14
	200-205	8.5	1.40	1.64	284	13	15	17	12.3	0.8	0.4	0.5	14	16	19
	205-210	8.6	1.52	1.53	258	10	16	14	11.2	0.6	0.4	0.4	12	15	20
	210-215	8.6	1.47	1.35	235	10	13	14	10.2	0.6	0.3	0.4	11	14	18
	215-220	8.6	1.53	1.39	243	10	18	18	10.6	0.6	0.5	0.5	12	14	19
	220-225	8.7	1.51	1.39	229	18	11	17	10.0	1.1	0.3	0.5	11	14	13
	225-230	8.8	1.37	1.36	239	9	8	18	10.4	0.6	0.2	0.5	11	14	20
	230-235	8.6	1.53	1.65	294	8	8	23	12.8	0.5	0.2	0.6	13	17	26
	235-240	8.6	1.70	1.67	298	9	11	18	13.0	0.6	0.3	0.5	14	17	24
	240-245	8.8	2.05	2.01	354	12	10	13	15.4	0.8	0.3	0.4	16	20	25
	245-250	8.7	2.10	2.22	377	15	9	12	16.4	0.9	0.2	0.3	18	22	24
	250-255														
	255-260	9.0	1.65	1.58	273	15	7	31	11.9	0.9	0.2	0.9	13	16	17
	260-265	9.3	1.49	1.42	252	7	6	31	11.0	0.4	0.2	0.9	12	14	23
	265-270	9.0	1.74	1.72	313	7	6	40	13.6	0.4	0.2	1.1	14	17	29
	270-275	8.9	1.53	1.69	300	15	8	35	13.0	0.9	0.2	1.0	14	17	19
	275-280	8.9	1.71	1.89	325	23	10	61	14.1	1.4	0.3	1.7	16	19	17
	280-285	9.0	1.97	2.10	365	21	10	49	15.9	1.3	0.3	1.4	17	21	20
	285-290	9.0	1.95	2.08	374	11	10	47	16.3	0.7	0.3	1.3	17	21	28
	290-295	8.9	1.93	2.09	377	11	7	41	16.4	0.7	0.2	1.2	17	21	28
	295-300	8.7	2.20	2.25	373	17	8	33	16.2	1.1	0.2	0.9	17	23	22
87-OK-103	0-2.5	9.0	0.52	0.58	81	21	8	10	3.5	1.3	0.2	0.3	5	6	4
	2.5-5.0	8.2	2.55	3.69	171	629	25	17	7.4	39.3	0.6	0.5	47	37	2
	5.0-7.5	8.2	2.79	3.98	191	666	26	16	8.3	41.6	0.7	0.5	51	40	2
	7.5-10.0	8.2	3.45	4.84	396	649	32	32	17.2	40.6	0.8	0.9	59	48	4
	10.0-12.5	8.1	3.21	4.46	361	608	34	61	15.7	38.0	0.9	1.7	55	45	4
	12.5-15.0	8.1	2.62	3.71	295	483	34	73	12.8	30.2	0.9	2.1	44	37	3
	15.0-17.5	8.2	1.45	1.97	158	195	28	38	6.9	12.2	0.7	1.1	20	20	3
	17.5-20	8.1	2.06	2.94	231	354	32	66	10.0	22.1	0.8	1.9	33	29	3
	20-25	8.1	1.32	1.81	151	188	25	33	6.6	11.8	0.6	0.9	19	18	3
	25-30	8.1	1.32	1.76	130	205	27	19	5.7	12.8	0.7	0.5	19	18	2
	30-35	8.1	1.56	2.04	127	292	34	11	5.5	18.3	0.9	0.3	25	20	2
	35-40	7.9	1.96	2.68	141	443	40	20	6.1	27.7	1.0	0.6	35	27	2
	40-45	7.9	2.24	2.86	157	475	39	24	6.8	29.7	1.0	0.7	38	29	2
	45-50	7.8	2.50	3.16	166	541	34	19	7.2	33.8	0.9	0.5	42	32	2
	50-55	7.9	2.34	3.02	177	502	38	26	7.7	31.4	1.0	0.7	40	30	2
	55-60	7.9	2.34	3.00	174	493	37	27	7.6	30.8	0.9	0.8	39	30	2
	60-65	7.9	2.33	3.14	191	520	40	22	8.3	32.5	1.0	0.6	42	31	2
	65-70	7.9	2.13	2.81	175	428	39	24	7.6	26.8	1.0	0.7	35	28	2
	70-75	8.2	1.76	2.32	167	314	33	23	7.3	19.6	0.8	0.6	28	23	2
	75-80	8.0	2.28	2.85	186	432	35	27	8.1	27.0	0.9	0.8	36	29	2
	80-85	7.9	2.14	2.85	189	432	32	20	8.2	27.0	0.8	0.6	36	29	2
	85-90	7.9	2.21	2.98	202	456	32	22	8.8	28.5	0.8	0.6	38	30	2
	90-95	7.9	2.44	3.10	198	491	38	23	8.6	30.7	1.0	0.6	40	31	2
	95-100	7.9	2.38	2.98	182	465	36	22	7.9	29.1	0.9	0.6	38	30	2

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-103	100-105	7.9	2.36	2.95	184	468	35	16	8.0	29.3	0.9	0.5	38	30	2
	105-110	8.0	2.42	3.07	187	486	35	14	8.1	30.4	0.9	0.4	39	31	2
	110-115	7.9	2.40	2.98	183	461	34	15	8.0	28.8	0.9	0.4	38	30	2
	115-120	8.0	2.21	2.77	182	413	38	14	7.9	25.8	1.0	0.4	35	28	2
	120-125	8.1	1.34	1.77	144	196	29	8	6.3	12.3	0.7	0.2	19	18	3
	125-130	8.1	1.42	1.87	140	225	27	9	6.1	14.1	0.7	0.3	21	19	2
	130-135	8.0	2.22	2.73	179	424	31	16	7.8	26.5	0.8	0.5	35	27	2
	135-140	8.0	2.32	2.95	178	473	32	21	7.7	29.6	0.8	0.6	38	30	2
	140-145	8.1	2.32	2.87	163	481	30	18	7.1	30.1	0.8	0.5	38	29	2
	145-150	8.1	2.28	2.88	164	472	30	17	7.1	29.5	0.8	0.5	37	29	2
	150-155	8.1	2.26	2.81	149	476	29	15	6.5	29.8	0.7	0.4	37	28	2
	155-160	8.1	1.76	2.17	125	322	26	20	5.4	20.1	0.7	0.6	26	22	2
	160-165	8.1	1.69	2.07	113	321	25	14	4.9	20.1	0.6	0.4	26	21	2
	165-170	8.2	1.52	1.79	88	265	27	12	3.8	16.6	0.7	0.3	21	18	1
	170-175	8.2	1.35	1.32	69	198	26	7	3.0	12.4	0.7	0.2	16	13	1
	175-180	8.3	1.22	1.07	56	149	25	6	2.4	9.3	0.6	0.2	12	11	1
	180-185	8.5	1.16	1.03	56	132	22	4	2.4	8.3	0.6	0.1	11	10	1
	185-190	8.3	1.47	1.35	67	209	25	5	2.9	13.1	0.6	0.1	17	14	1
	190-195														
	195-200														
	200-205														
	205-210														
	210-215														
	215-220														
	220-225	8.2	1.54	1.70	86	242	25	4	3.7	15.1	0.6	0.1	20	17	1
	225-230														
	230-235														
	235-240														
	240-245	8.5	1.27	1.35	78	194	19	3	3.4	12.1	0.5	0.1	16	14	1
	245-250	8.1	1.41	1.71	87	246	26	4	3.8	15.4	0.7	0.1	20	17	1
	250-255	8.1	1.75	2.07	117	309	31	3	5.1	19.3	0.8	0.1	25	21	2
	255-260														
	260-265														
	265-270														
	270-275														
	275-280														
	280-285	8.2	1.58	1.86	109	262	27	3	4.7	16.4	0.7	0.1	22	19	2
	285-290	8.1	1.70	2.03	127	277	31	3	5.5	17.3	0.8	0.1	24	20	2
	290-295														
	295-300														
	300-305														
	305-310	8.4	1.22	1.25	148	92	9	10	6.4	5.8	0.2	0.3	12	13	4
	310-315														
	315-320														
	320-325	8.4	1.23	1.31	212	43	9	25	9.2	2.7	0.2	0.7	12	13	8
	325-330	8.3	1.50	1.82	254	45	10	17	11.0	2.8	0.3	0.5	14	16	9
	330-335	8.6	1.11	1.20	212	27	6	41	9.2	1.7	0.2	1.2	11	13	10
	335-340	8.5	1.18	1.47	238	33	5	52	10.3	2.1	0.1	1.5	13	15	10
	340-345	8.5	1.40	1.66	281	36	6	48	12.2	2.3	0.2	1.4	15	17	12
	345-350	8.2	1.69	2.10	336	71	7	47	14.6	4.4	0.2	1.3	19	21	10
	350-355	8.3	2.41	3.09	545	87	10	46	23.7	5.4	0.3	1.3	29	31	14
	355-360	8.6	1.63	1.92	347	23	6	58	15.1	1.4	0.2	1.6	17	19	18
	360-365	8.1	2.74	3.95	624	239	11	88	27.1	14.9	0.3	2.4	42	40	10
	365-370	8.2	1.82	2.43	376	117	11	61	16.3	7.3	0.3	1.7	24	24	9
	370-375	8.5	1.83	2.26	458	9	7	77	19.9	0.6	0.2	2.2	21	23	38
	375-380	8.4	1.91	2.11	424	6	7	77	18.4	0.4	0.2	2.2	19	21	43
	380-385	8.5	1.57	1.78	353	6	6	70	15.3	0.4	0.2	2.2	16	18	35
	385-390	8.4	1.91	2.17	442	7	8	95	19.2	0.4	0.2	2.7	20	22	41
	390-395	8.3	2.56	3.32	664	22	14	91	28.9	1.4	0.4	2.6	31	33	35
	395-400	8.3	2.52	3.70	758	36	18	93	33.0	2.3	0.5	2.6	36	37	31
	400-405	8.3	2.78	3.82	780	33	17	97	33.9	2.1	0.4	2.7	36	38	33
	405-410	8.3	2.70	3.54	721	26	14	87	31.3	1.6	0.4	2.5	33	35	35
	410-415	8.3	2.61	3.33	676	23	14	84	29.4	1.4	0.4	2.4	31	33	35
	415-420	8.3	3.23	4.27	879	48	18	113	38.2	3.0	0.5	3.2	42	43	31
87-OK-104	0-2.5	8.4	0.61	0.67	55	66	18	17	2.4	4.1	0.5	0.5	7	7	2
	2.5-5.0	8.1	1.82	2.62	81	520	17	19	3.5	32.5	0.4	0.5	36	26	1
	5.0-7.5	7.8	3.12	4.88	382	821	30	46	16.6	51.3	0.8	1.3	69	49	3
	7.5-10.0	8.0	2.80	4.69	415	729	37	55	18.0	45.6	0.9	1.5	65	47	4
	10.0-12.5	7.9	2.96	4.62	387	760	46	51	16.8	47.5	1.2	1.4	66	46	3
	12.5-15.0	8.0	2.91	4.03	309	683	36	33	13.4	42.7	0.9	0.9	57	40	3
	15.0-17.5	8.0	2.71	4.13	329	660	41	48	14.3	41.3	1.1	1.4	57	41	3

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-104	17.5-20	8.0	2.61	3.87	326	596	41	41	14.2	37.3	1.1	1.2	52	39	3
	20-25	8.0	2.15	3.13	290	429	36	41	12.6	26.8	0.9	1.2	40	31	3
	25-30	8.1	1.46	1.97	232	168	27	30	10.1	10.5	0.7	0.8	21	20	4
	30-35	8.2	1.50	2.02	236	179	27	34	10.3	11.2	0.7	1.0	22	20	4
	35-40	8.1	1.63	2.26	265	214	26	41	11.5	13.4	0.7	1.2	26	23	4
	40-45	8.0	1.93	3.02	328	342	30	36	14.3	21.4	0.8	1.0	36	30	4
	45-50	8.0	1.96	2.66	314	255	26	34	13.7	15.9	0.7	1.0	30	27	5
	50-55	8.1	1.76	2.26	286	195	23	27	12.4	12.2	0.6	0.8	25	23	5
	55-60	7.9	1.67	2.20	289	167	21	21	12.6	10.4	0.5	0.6	24	22	6
	60-65	8.0	1.81	2.24	290	168	21	21	12.6	10.5	0.5	0.6	24	22	6
	65-70	8.0	1.79	2.56	331	215	23	19	14.4	13.4	0.6	0.5	28	26	6
	70-75	8.0	1.74	2.66	334	226	29	23	14.5	14.3	0.7	0.6	30	27	5
	75-80	8.0	1.97	2.87	362	264	29	20	15.7	16.5	0.7	0.6	33	29	5
	80-85	8.0	1.71	2.58	330	209	26	23	14.3	13.1	0.7	0.6	28	26	6
	85-90	8.0	1.74	2.78	370	228	25	26	16.1	14.3	0.6	0.7	31	28	6
	90-95	8.1	1.75	2.68	373	202	25	24	16.2	12.6	0.6	0.7	29	27	6
	95-100	8.0	1.81	2.85	388	230	24	22	16.9	14.4	0.6	0.6	32	29	6
	100-105	8.1	1.60	2.45	357	161	22	25	15.5	10.1	0.6	0.7	26	25	7
	105-110	8.0	1.88	2.81	392	207	22	20	17.0	12.9	0.6	0.6	31	28	7
	110-115	8.1	1.98	2.01	339	69	15	28	14.7	4.3	0.4	0.8	19	20	10
	115-120	8.2	1.63	1.69	325	35	49	28	14.1	2.2	1.3	0.8	18	17	14
	120-125	8.1	2.04	2.19	389	81	19	51	16.9	5.1	0.5	1.4	22	22	11
	125-130	8.2	2.48	2.97	504	123	29	82	21.9	7.7	0.7	2.3	30	30	11
	130-135	5.1	4.23	5.56	803	592	39	24	34.9	37.0	1.0	0.7	73	56	8
	135-140	7.5	2.70	3.46	521	236	21	26	22.7	14.8	0.5	0.7	38	35	8
	140-145	7.8	3.41	4.28	676	294	23	22	29.4	18.4	0.6	0.6	48	43	10
	145-150	7.8	2.93	3.93	611	292	21	23	26.6	18.3	0.5	0.6	45	39	9
	150-155	7.3	3.89	5.11	784	438	25	23	34.1	27.4	0.6	0.6	62	51	9
	155-160	7.4	3.39	4.83	647	488	25	28	28.1	30.5	0.6	0.8	59	48	7
	160-165														
	165-170	6.4	4.04	5.58	897	482	17	28	39.0	30.1	0.4	0.8	70	58	10
	170-175	6.5	4.50	6.15	1017	474	19	63	44.2	29.6	0.5	1.8	74	62	11
	175-180	6.5	4.68	6.36	1090	488	26	24	47.4	30.5	0.7	0.7	79	64	12
	180-185	7.1	4.63	6.11	1017	431	26	24	44.2	26.9	0.7	0.7	72	61	12
	185-190	7.3	4.60	6.12	1047	416	26	27	45.5	26.0	0.7	0.8	72	61	13
	190-195	7.6	4.24	5.65	973	343	17	23	42.3	21.4	0.4	0.6	64	57	13
	195-200	9.1	3.29	3.01	611	41	11	25	26.6	2.6	0.3	0.7	29	30	23
	200-205	7.4	4.43	5.66	1013	330	28	24	44.0	20.6	0.7	0.7	65	57	14
	205-210	7.4	4.29	5.53	942	345	33	25	41.0	21.6	0.8	0.7	63	55	12
	210-215	7.1	4.60	5.58	1030	307	57	15	44.8	19.2	1.5	0.4	65	56	14
	215-220	7.2	4.55	5.49	973	297	49	15	42.3	18.6	1.3	0.4	62	55	14
	220-225	7.3	4.58	5.91	1086	299	49	15	47.2	18.7	1.3	0.4	67	59	15
	225-230	8.0	3.75	4.48	879	117	38	18	38.2	7.3	0.9	0.5	46	45	20
	230-235	7.6	4.86	5.96	1169	236	50	18	50.8	14.8	1.3	0.5	67	60	19
	235-240	7.7	3.84	5.10	1022	141	23	23	44.4	8.8	0.6	0.6	54	51	21
	240-245	7.8	4.18	5.66	1113	203	24	23	48.4	12.7	0.6	0.6	62	57	19
	245-250	7.4	5.10	6.92	1376	308	33	19	59.8	19.3	0.8	0.5	80	69	19
	250-255	7.5	5.51	7.27	1480	287	36	20	64.3	17.9	0.9	0.6	83	73	21
	255-260	7.4	5.00	6.74	1370	257	39	24	59.6	16.1	1.0	0.7	77	67	21
	260-265	7.8	4.06	5.19	919	279	31	16	40.0	17.4	0.8	0.5	58	52	14
	265-270	7.4	4.44	5.59	1131	182	38	16	49.2	11.4	1.0	0.5	62	56	21
	270-275	7.8	4.54	5.83	1145	184	39	39	49.8	10.3	1.0	1.1	61	56	22
	275-280	8.2	5.59	7.24	1600	316	71	22	69.6	19.8	1.8	0.6	91	72	22
	280-285	7.4	5.00	6.46	1258	265	43	20	54.7	16.6	1.1	0.6	72	65	19
	285-290	6.9	6.17	7.98	1736	391	69	34	75.5	24.4	1.8	1.0	102	80	22
	290-295	6.9	5.90	8.25	1757	394	61	33	76.4	24.6	1.6	0.9	103	83	22
	295-300														
	300-305	8.1	4.28	5.34	1056	151	35	28	45.9	9.4	0.9	0.8	56	53	21
	305-310	8.2	4.37	5.20	1091	93	35	26	47.4	5.8	0.9	0.7	54	52	28
	310-315	8.1	4.65	5.75	1217	106	38	28	52.9	6.6	1.0	0.8	61	58	29
	315-320	8.2	4.40	5.11	1069	76	34	19	46.5	4.8	0.9	0.5	52	51	30
	320-325	8.2	4.21	4.93	1026	86	33	17	44.6	5.4	0.8	0.5	51	49	27
	325-330	8.2	4.04	5.06	1069	83	32	18	46.5	5.2	0.8	0.5	52	51	29
	330-335	8.1	4.33	5.10	1082	88	33	20	47.0	5.5	0.8	0.6	53	51	28
	335-340	7.9	4.48	5.47	1150	109	34	19	50.0	6.8	0.9	0.5	58	55	27
	340-345	8.0	4.13	5.00	1022	109	30	17	44.4	6.8	0.8	0.5	52	50	24
	345-350	8.1	4.11	4.86	1014	76	33	15	44.1	4.8	0.8	0.4	50	49	29
	350-355	7.8	4.77	6.29	1310	153	32	25	57.0	9.6	0.8	0.7	67	63	26
	355-360	8.0	4.27	5.63	1178	126	26	29	51.2	7.9	0.7	0.8	60	56	26
	360-365	7.9	4.49	5.88	1237	129	34	22	53.8	8.1	0.9	0.6	63	59	27
	365-370														
	370-375	8.2	3.09	3.68	736	64	18	19	32.0	4.0	0.5	0.5	36	37	23

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						---------mg/L--------				---------meq/L--------			--meq/L--		
87-OK-104	375-380	7.8	4.27	5.75	1178	169	28	25	51.2	10.6	0.7	0.7	62	58	22
	380-385	7.9	4.55	5.85	1187	161	33	19	51.6	10.1	0.8	0.5	63	59	23
	385-390	7.8	4.57	5.99	1227	184	35	18	53.3	11.5	0.9	0.5	66	60	22
	390-395	7.6	4.59	6.40	1315	193	41	19	57.2	12.1	1.1	0.5	70	64	23
	395-400	7.6	4.54	6.19	1257	179	38	76	54.7	11.2	1.0	2.1	67	62	23
	400-405	7.6	4.23	5.65	1094	238	27	21	47.6	14.9	0.7	0.6	63	57	17
	405-410														
	410-415	8.3	3.08	4.10	805	102	21	18	35.0	6.4	0.5	0.5	42	41	20
	415-420	8.2	2.73	3.65	718	72	18	20	31.2	4.5	0.5	0.6	36	37	21
	420-425	7.7	3.46	4.87	944	161	30	18	41.0	10.1	0.8	0.5	52	49	18
	425-430	7.7	3.57	4.78	922	156	30	15	40.1	9.8	0.8	0.4	51	48	18
	430-435	8.2	2.25	2.95	597	27	18	39	26.0	1.7	0.5	1.1	28	30	28
	435-440	8.2	2.16	3.15	681	27	19	32	29.6	1.7	0.5	0.9	32	32	32
	440-445	8.3	2.20	2.68	546	19	15	15	23.7	1.2	0.4	0.4	25	27	31
	445-450	8.3	2.32	2.96	612	21	15	19	26.6	1.3	0.4	0.5	28	30	33
	450-455	8.4	2.12	3.13	643	13	14	33	28.0	0.8	0.4	0.9	29	31	44
	455-460	8.4	2.00	2.41	503	10	10	29	21.9	0.6	0.3	0.8	23	24	39
	460-465	8.4	2.28	2.68	560	13	12	33	24.3	0.6	0.3	0.9	25	27	38
	465-470	8.3	2.18	2.56	537	12	11	43	23.3	0.8	0.3	1.2	24	26	38
	470-475	8.3	2.21	2.60	549	12	10	50	23.9	0.8	0.3	1.4	25	26	39
	475-480	8.5	2.29	2.52	533	10	10	50	23.2	0.6	0.3	1.4	24	25	41
	480-485	8.5	2.58	3.15	651	15	13	47	28.3	0.9	0.3	1.3	30	32	41
	485-490	8.5	2.13	2.23	447	8	10	53	19.4	0.5	0.3	1.5	20	22	39
	490-495	8.5	2.29	2.81	576	13	9	75	25.0	0.8	0.2	2.1	26	28	39
	495-500	8.6	2.05	2.20	446	5	5	83	19.4	0.3	0.1	2.3	20	22	49
	500-505	8.6	2.26	2.56	514	10	8	67	22.3	0.6	0.2	1.9	23	26	40
	505-510	8.4	2.62	3.32	670	17	9	8	29.1	1.1	0.2	0.2	30	33	40
	510-515	8.5	2.24	2.36	499	7	6	10	21.7	0.4	0.2	0.3	22	24	46
	515-520	8.4	2.25	2.43	495	6	6	10	21.5	0.4	0.2	0.3	22	24	50
	520-525	8.5	2.51	2.81	598	8	8	13	26.0	0.5	0.2	0.4	27	28	52
	525-530	8.4	2.59	2.70	572	7	7	16	24.9	0.4	0.2	0.5	25	27	53
	530-535	8.4	2.60	2.90	608	9	7	15	26.3	0.6	0.2	0.4	27	29	50
	535-540	8.4	2.71	3.08	647	11	7	18	28.1	0.7	0.2	0.5	29	31	48
87-OK-105	0-2.5	8.1	3.83	6.38	846	712	7	39	36.8	44.5	0.2	1.1	81	64	8
	2.5-5.0	8.5	2.77	4.15	591	377	10	22	25.7	23.6	0.3	0.6	50	42	7
	5.0-7.5	8.4	2.17	3.34	444	308	14	24	19.3	19.3	0.4	0.7	39	33	6
	7.5-10.0	8.1	3.51	4.57	301	788	16	14	13.1	49.3	0.4	0.4	63	46	3
	10.0-12.5	8.1	3.56	4.54	330	753	16	13	14.3	47.1	0.4	0.4	62	45	3
	12.5-15.0	8.0	2.37	3.53	213	605	17	20	9.3	37.8	0.4	0.6	48	35	2
	15.0-17.5	8.0	2.23	3.27	179	578	17	20	7.8	36.1	0.4	0.6	44	33	2
	17.5-20	8.0	2.19	3.32	180	573	19	22	7.8	35.8	0.5	0.6	44	33	2
	20-25	8.0	1.98	2.96	195	472	17	21	8.5	29.5	0.4	0.6	38	30	2
	25-30	8.0	2.05	2.88	143	499	20	16	6.2	31.2	0.5	0.5	38	29	2
	30-35	8.2	0.93	1.12	49	175	17	9	2.1	10.9	0.4	0.3	14	11	1
	35-40	8.4	0.54	0.64	32	86	14	7	1.4	5.4	0.4	0.2	7	6	1
	40-45	8.9	0.44	0.51	45	47	13	6	2.0	2.9	0.3	0.2	5	5	2
	45-50	8.8	0.52	0.51	38	52	15	5	1.7	3.3	0.4	0.1	5	5	1
	50-55	8.6	1.73	2.27	90	403	23	4	3.9	25.2	0.6	0.1	30	23	1
	55-60	8.6	1.38	1.84	91	279	20	9	4.0	17.4	0.5	0.3	22	18	1
	60-65	8.6	1.15	1.36	82	200	19	6	3.6	12.5	0.5	0.2	17	14	1
	65-70	8.8	0.73	0.75	59	79	14	9	2.6	4.9	0.4	0.3	8	8	2
	70-75	8.7	0.49	0.45	34	43	14	9	1.5	2.7	0.4	0.3	5	5	1
	75-80	8.7	0.45	0.41	31	37	13	7	1.3	2.3	0.3	0.2	4	4	1
	80-85	8.6	0.50	0.48	33	49	13	6	1.4	3.1	0.3	0.2	5	5	1
	85-90	8.5	0.45	0.45	36	42	14	8	1.6	2.6	0.4	0.2	5	5	1
	90-95	8.7	0.60	0.55	46	50	16	8	2.0	3.1	0.5	0.2	6	6	2
	95-100	8.7	0.55	0.51	43	42	17	8	2.0	2.6	0.4	0.2	5	5	2
	100-105	8.8	0.86	0.73	70	64	17	9	3.0	4.0	0.4	0.3	7	7	2
	105-110	8.9	0.82	0.70	71	55	13	9	3.1	3.4	0.3	0.3	7	7	2
	110-115	8.9	0.93	0.83	87	67	14	12	3.8	4.2	0.4	0.3	8	8	3
	115-120	8.9	0.90	0.89	114	49	12	9	5.0	3.1	0.3	0.3	8	9	4
	120-125	9.1	1.13	1.08	159	44	11	8	6.9	2.8	0.3	0.2	10	11	6
	125-130	9.1	1.43	1.39	206	61	18	10	9.0	3.8	0.5	0.3	13	14	6
	130-135	8.9	1.12	1.15	171	46	12	9	7.4	2.9	0.3	0.3	11	12	6
	135-140	8.9	1.53	1.57	235	58	16	11	10.2	3.6	0.4	0.3	14	16	8
	140-145	8.9	1.33	1.48	225	49	12	10	9.8	3.1	0.3	0.3	13	15	8
	145-150	8.9	1.48	1.72	262	63	11	9	11.4	3.9	0.3	0.3	16	17	8
	150-155	8.9	1.37	1.53	241	46	12	11	10.5	2.9	0.3	0.3	14	15	9
	155-160	8.8	1.46	1.65	261	52	10	11	11.3	3.3	0.3	0.3	15	17	9
	160-165	8.9	1.43	1.65	262	48	17	15	11.4	3.0	0.4	0.4	15	17	9
	165-170	8.9	1.38	1.57	248	43	13	12	10.8	2.7	0.3	0.3	14	16	9

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						---------mg/L---------				---------meq/L---------			--meq/L--		
87-OK-105	170-175	9.0	1.13	1.25	208	26	14	13	9.0	1.6	0.4	0.4	11	13	10
	175-180	9.0	1.18	1.35	225	27	12	13	9.8	1.7	0.3	0.4	12	14	11
	180-185	8.9	1.43	1.66	287	40	15	12	11.6	2.5	0.4	0.3	14	17	10
	185-190	8.9	1.45	1.64	258	37	17	12	11.7	2.3	0.4	0.3	14	16	11
	190-195	9.1	1.50	1.58	275	34	13	12	12.0	2.1	0.3	0.3	14	16	12
	195-200	9.1	1.60	1.76	306	44	16	11	13.3	2.8	0.4	0.3	16	18	11
	200-205	9.1	1.45	1.71	296	35	19	25	12.9	2.2	0.5	0.7	16	17	12
	205-210	8.9	1.37	1.65	286	31	16	17	12.4	1.9	0.4	0.5	15	17	13
	210-215	9.0	0.92	1.03	187	12	7	9	8.1	0.8	0.2	0.3	9	10	13
	215-220	9.1	1.22	1.46	255	17	16	11	11.1	1.1	0.4	0.3	13	15	15
	220-225	9.0	1.19	1.47	256	17	13	12	11.1	1.1	0.3	0.3	13	15	15
	225-230	8.9	1.35	1.71	298	23	14	13	12.9	1.4	0.4	0.4	15	17	15
	230-235	8.9	1.48	1.85	322	27	18	12	14.0	1.7	0.5	0.3	16	19	15
	235-240														
	240-245														
	245-250	8.8	1.02	1.15	206	11	9	9	9.0	0.7	0.2	0.3	10	12	15
	250-255	9.1	1.25												
	255-260	9.2	1.00												
	260-265	9.1	0.97	1.09	201	5	11	16	8.7	0.3	0.3	0.5	9	11	22
	265-270	9.3	0.97	1.18	263	5		19	11.4	0.3		0.5	12	12	29
	270-275														
	275-280														
	280-285														
	285-290	9.4	1.40												
	290-295	9.4	1.19												
	295-300	9.6	1.12												
	300-305	9.8	1.06												
	305-310	9.7	1.58												
	310-315	9.6	1.12	1.16	252	2		25	11.0	0.1		0.7	11	12	44
	315-320	9.6	1.06	1.00	202	2	23	34	8.8	0.1	0.6	1.0	9	10	35
87-OK-106	0-2.5														
	2.5-5.0	8.3	0.95	0.98	134	53	7	13	5.8	3.3	0.2	0.4	9	10	5
	5.0-7.5	8.0	3.38	4.20	336	600	9	17	14.6	37.5	0.2	0.5	52	42	3
	7.5-10.0	8.1	4.59	5.78	519	725	9	28	22.6	45.3	0.2	0.8	68	58	5
	10.0-12.5	8.1	4.39	5.35	455	680	9	24	19.8	42.5	0.2	0.7	63	54	4
	12.5-15.0	8.1	4.09	5.27	441	681	9	26	19.2	42.6	0.2	0.7	62	53	4
	15.0-17.5	8.0	3.37	4.36	270	623	13	16	11.7	38.9	0.3	0.5	51	44	3
	17.5-20	8.0	2.58	3.94	255	536	19	13	11.1	33.5	0.5	0.4	45	39	3
	20-25	8.0	2.59	3.70	232	516	20	16	10.1	32.3	0.5	0.5	43	37	3
	25-30	8.0	2.35	3.38	171	502	22	15	7.4	31.4	0.6	0.4	39	34	2
	30-35	8.1	1.42	1.74	88	220	19	6	3.8	13.8	0.5	0.2	18	17	1
	35-40	8.0	1.72	2.05	118	280	21	6	5.1	17.5	0.5	0.2	23	21	2
	40-45	8.0	1.85	2.22	151	282	22	6	6.6	17.6	0.6	0.2	25	22	2
	45-50	8.0	1.76	2.09	150	256	21	7	6.5	16.1	0.5	0.2	23	21	2
	50-55	8.1	1.38	1.53	118	156	16	6	5.1	9.8	0.4	0.2	15	15	2
	55-60	8.3	1.04	1.10	109	83	19	9	4.7	5.2	0.5	0.3	10	11	3
	60-65	8.4	1.65	1.95	130	216	23	6	5.7	13.5	0.6	0.2	20	20	2
	65-70	8.5	1.48	1.76	140	169	23	8	6.1	10.6	0.6	0.2	17	18	3
	70-75	8.6	1.30	1.62	145	134	21	10	6.3	8.4	0.5	0.3	15	16	3
	75-80	8.5	1.47	1.80	152	166	22	9	6.6	10.4	0.6	0.3	18	18	3
	80-85	8.5	1.64	1.98	160	192	22	10	7.0	12.0	0.6	0.3	20	20	3
	85-90	8.5	1.55	2.06	171	214	24	9	7.4	13.4	0.6	0.3	21	21	3
	90-95	8.6	1.72	2.25	185	287	24	9	8.0	17.9	0.6	0.3	27	23	3
	95-100	8.6	1.47	1.87	169	195	21	11	7.3	12.2	0.5	0.3	20	19	3
	100-105	8.7	1.56	2.02	189	231	22	10	8.2	14.4	0.6	0.3	23	20	3
	105-110	8.8	1.46	1.85	166	195	20	10	7.2	12.2	0.5	0.3	20	19	3
	110-115	8.7	1.78	2.29	204	289	21	11	8.9	18.1	0.5	0.3	27	23	3
	115-120	8.6	1.77	2.22	178	287	20	7	7.7	17.9	0.5	0.2	26	22	3
	120-125	8.8	0.91	1.02	139	50	11	10	6.0	3.1	0.3	0.3	9	10	5
	125-130	8.8	0.88	1.00	138	45	11	11	6.0	2.8	0.3	0.3	9	10	5
	130-135	8.8	0.92	1.03	150	44	13	10	6.5	2.8	0.3	0.3	10	10	6
	135-140	8.6	0.95	1.09	157	48	13	12	6.8	3.0	0.3	0.3	10	11	6
	140-145	8.8	0.91	1.02	155	35	14	13	6.7	2.2	0.4	0.4	9	10	6
	145-150														
	150-155														
	155-160	8.4	1.02	1.29	194	48	19	12	8.4	3.0	0.5	0.3	12	13	7
	160-165	8.5	0.95	1.06	164	32	18	15	7.1	2.0	0.5	0.4	10	11	7
	165-170														
	170-175														
	175-180	8.4	1.09	1.50	194	86	19	9	8.4	5.4	0.5	0.3	14	15	5
	180-185														

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-106	185-190														
	190-195														
	195-200	8.5	1.07	1.22	176	56	12	8	7.7	3.5	0.3	0.2	11	12	6
	200-205	8.7	0.88	1.09	158	41	13	7	6.9	2.6	0.3	0.2	10	11	6
	205-210	8.4	1.16	1.30	178	62	20	8	7.7	3.9	0.5	0.2	12	13	6
	210-215	8.3	1.11	1.25	164	69	19	5	7.1	4.3	0.5	0.1	12	13	5
	215-220	8.2	1.27	1.49	178	90	23	5	7.7	5.6	0.6	0.1	14	15	5
	220-225	8.3	1.42	1.66	205	101	23	6	8.9	6.3	0.6	0.2	16	17	5
	225-230	9.0	0.94	0.92	144	20	15	10	6.3	1.3	0.4	0.3	8	9	8
	230-235	8.7	0.76	0.81	119	25	12	13	5.2	1.6	0.3	0.4	7	8	6
	235-240	8.8	1.02	1.14	164	42	16	10	7.1	2.6	0.4	0.3	10	11	6
	240-245	9.0	0.79	0.83	128	17	11	11	5.6	1.1	0.3	0.3	7	8	8
	245-250	8.9	0.72	0.69	111	10	11	9	4.8	0.6	0.3	0.3	6	7	9
	250-255	8.7	0.87	0.95	141	33	13	7	6.1	2.1	0.3	0.2	9	10	6
	255-260														
	260-265														
	265-270														
	270-275														
	275-280	8.8	1.10	1.12	170	34	13	8	7.4	2.1	0.3	0.2	10	11	7
	280-285	8.8	1.11	1.19	187	27	12	8	8.1	1.7	0.3	0.2	10	12	9
	285-290														
	290-295	9.0	1.05	1.12	186	12	10	10	8.1	0.8	0.3	0.3	9	11	13
	295-300	9.0	1.13	1.15	201	8	8	11	8.7	0.5	0.2	0.3	9	12	17
87-OK-107	0-2.5	7.9	4.81	6.39	1006	402	7	19	43.7	25.1	0.2	0.5	69	63	12
	2.5-5.0	8.2	5.07	6.18	972	386	8	13	42.3	24.1	0.2	0.4	67	62	12
	5.0-7.5	8.2	6.42	8.14	1416	473	8	19	61.6	29.6	0.2	0.5	91	81	16
	7.5-10.0	8.2	5.53	7.46	1267	486	8	20	55.1	30.4	0.2	0.6	86	75	14
	10.0-12.5	8.0	4.47	6.32	997	468	11	23	43.3	29.3	0.3	0.6	73	63	11
	12.5-15.0	8.1	3.26	4.91	819	261	10	23	35.6	16.3	0.3	0.6	52	49	12
	15.0-17.5	8.6	1.27	1.75	298	23	10	14	13.0	1.4	0.3	0.4	15	18	15
	17.5-20	8.5	1.00	1.28	221	14	10	14	9.6	0.9	0.3	0.4	11	13	15
	20-25	8.7	1.09	1.15	191	20	10	16	8.3	1.3	0.3	0.5	10	12	11
	25-30	8.9	0.92	0.98	162	12	12	11	7.0	0.8	0.3	0.3	8	10	12
	30-35	8.9	0.93	1.08	179	14	12	12	7.8	0.9	0.3	0.3	9	11	12
	35-40	8.9	0.97	1.18	187	25	9	9	8.1	1.6	0.2	0.3	10	12	9
	40-45	9.1	0.77	0.87	143	16	11	18	6.2	1.0	0.3	0.5	7	9	9
	45-50	9.7	0.86	0.76	121	14	5	12	5.3	0.9	0.1	0.3	6	8	8
	50-55	9.6	0.83	0.75	125	6	5	9	5.4	0.4	0.1	0.3	6	8	13
	55-60	9.0	1.24	1.29	211	18	7	11	9.2	1.1	0.2	0.3	10	13	12
	60-65	9.0	1.15	1.19	192	19	6	8	8.3	1.2	0.2	0.2	10	12	11
	65-70	9.1	1.05	1.12	180	14	6	9	7.8	0.9	0.2	0.3	9	11	12
	70-75	8.8	1.47	1.53	239	29	7	11	10.4	1.8	0.2	0.3	12	15	11
	75-80	8.8	1.32	1.42	228	17	8	12	9.9	1.1	0.2	0.3	11	14	14
	80-85	9.0	1.18	1.28	211	19	5	11	9.2	1.2	0.1	0.3	10	13	12
	85-90	8.8	1.29	1.45	239	15	7	12	10.4	0.9	0.2	0.3	12	15	15
	90-95	8.9	1.22	1.25	203	18	6	11	8.8	1.1	0.2	0.3	10	13	12
	95-100	9.1	1.23	1.20	193	17	7	13	8.4	1.1	0.2	0.4	10	12	12
87-OK-108	0-2.5	7.7	2.03	3.24	336	326	13	17	14.6	20.4	0.3	0.5	35	32	5
	2.5-5.0	8.2	0.97	1.41	210	34	17	19	9.1	2.1	0.4	0.5	12	14	9
	5.0-7.5	8.1	1.02	1.50	221	50	14	13	9.6	3.1	0.4	0.4	13	15	8
	7.5-10.0	7.7	2.46	3.66	339	412	16	23	14.7	25.8	0.4	0.6	41	37	4
	10.0-12.5	8.2	1.11	1.55	221	51	12	13	9.6	3.2	0.3	0.4	13	16	8
	12.5-15.0	8.2	0.84	1.13	192	32	14	14	8.3	2.0	0.4	0.4	11	11	8
	15.0-17.5	8.5	0.86	1.03	182	21	13	15	7.9	1.3	0.3	0.4	10	10	10
	17.5-20	8.6	0.89	1.12	190	23	11	11	8.3	1.4	0.3	0.3	10	11	10
	20-25	8.8	0.86	0.93	152	16	7	9	6.6	1.0	0.2	0.3	8	9	9
	25-30	8.9	0.81	0.88	141	16	7	9	6.1	1.0	0.2	0.3	7	9	9
	30-35	8.6	1.21	1.26	202	26	9	12	8.8	1.6	0.2	0.3	11	13	10
	35-40	8.8	1.16	1.17	188	23	8	12	8.2	1.4	0.2	0.3	10	12	10
	40-45	8.7	1.29	1.29	211	21	11	11	9.2	1.3	0.3	0.3	11	13	11
	45-50	9.1	1.15	1.17	188	19	8	10	8.2	1.2	0.2	0.3	10	12	11
	50-55	8.9	1.35	1.42	220	24	9	10	9.6	1.5	0.2	0.3	11	14	11
	55-60	9.0	1.29	1.40	221	19	9	11	9.6	1.2	0.2	0.3	11	14	12
	60-65	9.3	0.98	0.97	154	14	9	12	6.7	0.9	0.2	0.3	8	10	10
	65-70	9.2	1.04	1.07	175	10	12	15	7.6	0.6	0.3	0.4	9	11	14
	70-75	9.2	1.29	1.38	219	14	11	12	9.5	0.9	0.3	0.3	11	14	14
	75-80	9.3	1.15	1.21	196	11	8	11	8.5	0.7	0.2	0.3	9	12	15
	80-85	9.2	1.24	1.30	211	12	8	11	9.2	0.8	0.2	0.3	10	13	15
	85-90	9.5	1.22	1.23	202	15	8	9	8.8	0.9	0.2	0.3	10	12	13
	90-95	9.3	1.40	1.48	238	12	10	11	10.3	0.8	0.3	0.3	11	15	17

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-108	95-100	9.6	1.26	1.23	198	11	8	13	8.6	0.7	0.2	0.4	10	12	15
87-OK-109	0-2.5	8.0	8.09	12.35	2358	707	21	74	102.5	44.2	0.5	2.1	147	124	22
	2.5-5.0	8.0	6.36	9.37	1606	673	19	51	69.8	42.1	0.5	1.4	112	94	15
	5.0-7.5	8.0	4.72	7.41	1229	503	20	46	53.4	31.4	0.5	1.3	85	74	13
	7.5-10.0	8.0	4.95	7.75	1207	604	20	37	52.5	37.8	0.5	1.0	91	78	12
	10.0-12.5	8.0	5.88	8.81	1441	662	20	40	62.7	41.4	0.5	1.1	105	88	14
	12.5-15.0	7.9	5.86	8.50	1380	624	22	41	60.0	39.0	0.6	1.2	100	85	14
	15.0-17.5	7.7	5.27	7.56	1228	532	21	42	53.4	33.3	0.5	1.2	87	76	13
	17.5-20	6.6	4.83	6.74	1084	523	19	33	47.1	32.7	0.5	0.9	80	67	12
	20-25	7.1	4.40	6.04	873	474	22	46	38.0	29.6	0.6	1.3	68	60	10
	25-30	8.4	2.68	3.53	585	119	17	28	25.4	7.4	0.4	0.8	33	35	13
	30-35	9.1	1.70	1.85	320	18	33	23	13.9	1.1	0.8	0.6	16	19	19
	35-40	9.2	1.55	1.82	313	17	23	18	13.6	1.1	0.6	0.5	15	18	19
	40-45	9.5	1.34	1.45	248	10	21	23	10.8	0.6	0.5	0.6	12	15	19
	45-50	9.5	1.28	1.51	262	11	35	25	11.4	0.7	0.9	0.7	13	15	19
	50-55	9.5	1.31	1.46	252	10	28	20	11.0	0.6	0.7	0.6	12	15	20
	55-60	9.5	1.30	1.28	221	6	23	30	9.6	0.4	0.6	0.8	11	13	22
	60-65	9.5	1.37	1.32	228	6	18	20	9.9	0.4	0.5	0.6	11	13	23
	65-70	9.4	1.26	1.20	206	5	23	13	9.0	0.3	0.6	0.4	10	12	23
	70-75	9.3	1.59	1.75	303	9	21	13	13.2	0.6	0.5	0.4	14	18	25
	75-80	9.5	1.38	1.37	227	5	11	8	9.9	0.3	0.3	0.2	10	14	25
	80-85	9.6	1.54	1.68	284	7	15	10	12.3	0.4	0.4	0.3	13	17	26
	85-90	9.7	1.42	1.32	232	5	24	25	10.1	0.3	0.6	0.7	11	13	26
	90-95	9.7	1.33	1.14	196	4	13	14	8.5	0.3	0.3	0.4	9	11	24
	95-100	9.7	1.51	1.51	264	5	21	20	11.5	0.3	0.5	0.6	12	15	29
	100-105	9.6	1.37	1.36	230	6	15	13	10.0	0.4	0.4	0.4	11	14	23
	105-110	9.6	1.44	1.41	234	9	14	22	10.2	0.6	0.4	0.6	11	14	19
	110-115	9.6	1.50	1.45	248	5	16	9	10.7	0.3	0.4	0.3	11	15	27
	115-120	9.6	1.42	1.46	255	5	31	21	11.1	0.3	0.8	0.6	12	15	28
87-OK-110	0-2.5	8.6	2.58	4.23	854	23	49	30	37.1	1.4	1.3	0.8	40	42	44
	2.5-5.0	8.8	0.48	0.74	136	3	40	14	5.9	0.2	1.0	0.4	7	7	19
	5.0-7.5	8.5	0.37	0.47	71	6	26	9	3.1	0.4	0.7	0.3	4	5	7
	7.5-10.0														
	10.0-12.5														
	12.5-15.0														
	15.0-17.5														
	17.5-20														
	20-25														
	25-30														
	30-35														
	35-40	8.4	0.36	0.45	35	35	26	17	1.5	2.2	0.7	0.5	4	5	1
	40-45	8.5	0.39	0.51	60	24	34	12	2.6	1.5	0.9	0.3	5	5	3
	45-50	8.5	0.40	0.53	66	22	36	33	2.9	1.4	0.9	0.9	5	5	3
	50-55	8.5	0.42	0.64	81	29	65	23	3.5	1.8	1.7	0.6	7	6	4
	55-60	8.5	0.49												
	60-65	8.6	0.60												
	65-70	8.7	0.66												
	70-75	8.7	0.73												
	75-80	8.7	0.71	0.96	148	30		27	6.4	1.9		0.8	8	10	7
	80-85	8.9	0.59	0.73	119	14	71	19	5.2	0.9	1.8	0.5	8	7	8
	85-90	8.9	0.65												
	90-95	8.8	0.68												
	95-100	9.2	0.66	0.79	131	12	26	42	5.7	0.8	0.7	1.2	7	8	9
	100-105	9.2	0.77	0.81	134	11	16	12	5.8	0.7	0.4	0.3	7	8	10
	105-110	9.2	0.77	0.85	140	14	26	13	6.1	0.9	0.7	0.4	8	9	9
	110-115	9.2	0.82	0.88	147	12	15	12	6.4	0.8	0.4	0.3	8	9	10
	115-120	9.2	0.86	0.95	157	14	16	12	6.8	0.9	0.4	0.3	8	10	10
87-OK-111	0-5	7.7	2.67	3.85	227	700	22	38	9.9	43.8	0.6	1.1	54	39	2
	5-10	8.0	2.89	4.13	284	755	24	40	11.5	47.2	0.6	1.1	59	41	2
	10-15	8.0	2.75	4.04	274	730	24	47	11.9	45.6	0.6	1.3	58	40	2
	15-20	8.0	2.83	3.99	241	767	22	34	10.5	47.9	0.6	1.0	59	40	2
	20-25	8.2	2.29	3.33	204	630	18	38	8.9	39.9	0.5	1.1	49	33	2
	25-30	8.2	2.59	3.85	247	736	19	49	10.7	46.0	0.5	1.4	57	39	2
	30-35	8.5	3.45	5.60	928	351	10	29	40.3	21.9	0.3	0.8	63	56	12
	35-40	8.4	3.48	5.60	983	30	14	29	42.7	19.3	0.4	0.8	62	56	14
	40-45	8.3	4.91	7.93	1393	581	20	34	60.6	36.7	0.5	1.0	98	79	14
	45-50	8.4	3.51	5.72	1046	293	20	43	45.5	18.3	0.5	1.2	64	57	15
	50-55	8.2	2.75	4.62	805	211	26	38	35.0	13.2	0.7	1.1	49	46	14
	55-60	8.0	2.58	4.81	828	244	28	40	36.0	15.3	0.7	1.1	52	48	13

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension extract		Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						---------mg/L---------				--------meq/L--------			--meq/L--		
87-OK-111	60-65	7.4	4.03	5.56	921	383	27	28	40.0	23.9	0.7	0.8	65	56	12
	65-70	7.5	4.17	5.58	899	417	32	28	39.1	26.1	0.8	0.8	66	56	11
	70-75	7.4	4.38	6.05	987	424	35	31	42.9	26.5	0.9	0.9	70	61	12
	75-80	7.6	3.63	4.77	849	178	23	29	36.9	11.1	0.6	0.8	49	48	16
	80-85	7.7	3.86	5.53	1021	198	23	24	44.4	12.4	0.6	0.7	57	55	18
	85-90	7.7	3.75	5.27	976	153	25	22	42.4	9.6	0.6	0.6	53	53	19
	90-95	7.4	4.09	5.54	1021	194	37	20	44.4	12.1	0.9	0.6	57	55	18
	95-100	7.4	3.85	5.60	1004	186	38	21	43.7	11.6	1.0	0.6	56	56	18
	100-105	7.4	3.76	5.72	1085	172	41	25	47.2	10.8	1.1	0.7	59	57	20
	105-110	7.4	3.70	5.77	1094	163	40	28	47.6	10.2	1.0	0.8	59	58	21
	110-115	7.4	3.47	5.80	1085	170	40	27	47.2	10.6	1.0	0.8	59	58	20
	115-120	7.4	4.46	6.43	1207	191	44	23	52.5	11.9	1.1	0.6	66	64	21
	120-125	8.1	3.70	5.11	972	81	33	23	42.3	5.1	0.8	0.6	48	51	27
	125-130	7.6	4.49	6.36	1222	152	33	29	53.1	9.5	0.8	0.8	63	64	24
	130-135	7.4	4.77	6.62	1283	184	29	27	55.8	11.5	0.7	0.8	68	66	23
	135-140	7.9	5.13	7.08	1445	156	30	30	62.8	9.8	0.8	0.8	73	71	28
	140-145	7.2	5.12	7.02	1402	219	42	28	61.0	13.7	1.1	0.8	76	70	23
	145-150	7.2	5.08	7.09	1414	235	58	33	61.5	14.7	1.5	0.9	78	71	23
	150-155	7.4	4.64	6.79	1335	182	40	35	58.0	11.4	1.0	1.0	70	68	24
	155-160	8.4	3.50	4.13	803	38	17	30	34.9	2.4	0.4	0.8	38	41	32
	160-165	7.3	5.53	7.62	1672	254	68	31	72.7	15.9	1.7	0.9	90	76	26
	165-170	7.1	5.55	7.53	1467	244	52	30	63.8	15.3	1.3	0.8	80	75	23
	170-175	7.1	5.80	7.80	1547	273	50	35	67.3	17.1	1.3	1.0	86	78	23
	175-180	8.2	4.02	5.39	1053	77	25	31	45.8	4.8	0.6	0.9	51	54	30
	180-185	7.3	5.35	7.41	1485	194	41	29	64.6	12.1	1.1	0.8	78	74	26
	185-190	7.3	5.41	7.62	1553	221	52	38	67.5	13.8	1.3	1.1	83	76	26
	190-195	7.3	5.66	7.57	1516	197	42	32	65.9	12.3	1.1	0.9	79	76	27
	195-200	7.3	5.66	7.55	1541	204	43	34	67.0	12.8	1.1	1.0	81	76	27
87-OK-112	0-5	8.0	2.57	3.62	188	590	17	23	8.2	36.9	0.4	0.6	45	36	2
	5-10	8.2	2.51	3.39	221	478	21	31	9.6	29.9	0.5	0.9	40	34	2
	10-15	8.2	2.29	3.18	208	430	19	34	9.0	26.9	0.5	1.0	36	32	2
	15-20	8.2	2.44	3.32	223	473	19	32	9.7	29.6	0.5	0.9	40	33	3
	20-25	8.2	2.31	3.19	195	472	16	40	8.5	29.5	0.4	1.1	38	32	2
	25-30	8.2	2.24	2.93	70	567	14	17	3.0	35.4	0.4	0.5	39	29	1
	30-35	8.1	2.41	3.14	83	620	13	18	3.6	38.8	0.3	0.5	43	31	1
	35-40	8.1	1.93	2.70	94	489	13	17	4.1	30.6	0.3	0.5	35	27	1
	40-45	8.4	1.26	1.63	148	156	9	9	6.4	9.8	0.2	0.3	16	16	3
	45-50	8.2	2.34	3.13	457	181	13	17	19.9	11.3	0.3	0.5	32	31	8
	50-55	8.0	2.34	3.06	478	133	13	16	20.8	8.3	0.3	0.5	29	31	10
	55-60	7.7	3.31	4.65	738	266	17	15	32.1	16.6	0.4	0.4	49	47	11
	60-65	7.4	3.94	5.82	1036	370	34	26	45.0	23.1	0.9	0.7	69	58	13
	65-70	7.4	3.72	5.70	1032	330	32	23	44.9	20.6	0.8	0.6	66	57	14
	70-75	7.5	3.79	6.11	1115	319	38	30	48.5	19.9	1.0	0.8	69	61	15
	75-80	7.6	3.57	5.21	916	237	37	26	39.8	14.8	0.9	0.7	56	52	15
87-OK-113	0-2.5														
	2.5-5.0														
	5.0-7.5														
	7.5-10.0														
	10.0-12.5														
	12.5-15.0														
	15.0-17.5														
	17.5-20	8.1	0.76	0.79	81	54	10	12	3.5	3.4	0.3	0.3	7	8	3
	20-25	8.2	0.71	0.69	45	75	10	19	2.0	4.7	0.3	0.5	7	7	1
	25-30														
	30-35	8.2	0.57	0.48	29	51	9	22	1.3	3.2	0.2	0.6	5	5	1
	35-40	8.2	0.71	0.74	26	109	14	11	1.1	6.8	0.4	0.3	8	7	1
	40-45	8.0	0.89	0.90	28	141	16	12	1.2	8.8	0.4	0.3	10	9	1
	45-50	8.0	0.97	1.01	31	167	18	12	1.3	10.4	0.5	0.3	12	10	1
	50-55	8.0	0.78	1.01	27	170	17	9	1.2	10.6	0.4	0.3	12	10	1
	55-60	8.1	0.80	0.96	30	157	16	8	1.3	9.8	0.4	0.2	12	10	1
	60-65	8.1	0.96	1.10	34	187	18	9	1.5	11.7	0.5	0.3	14	11	1
	65-70	8.0	0.93	1.13	36	191	17	9	1.6	11.9	0.4	0.3	14	11	1
	70-75	8.1	0.76	0.99	39	149	16	11	1.7	9.3	0.4	0.3	11	10	1
	75-80	8.1	0.89	1.15	49	184	17	11	2.1	11.5	0.4	0.3	14	12	1
	80-85	8.1	0.94	1.24	56	197	17	11	2.4	12.3	0.4	0.3	15	12	1
	85-90	8.0	1.19	1.66	75	247	19	19	3.3	15.4	0.5	0.5	19	17	1
	90-95	7.9	1.47	2.02	95	313	20	10	4.1	9.6	0.5	0.3	24	20	1
	95-100	8.0	1.15	1.64	97	221	17	12	4.2	13.8	0.4	0.3	18	16	2
	100-105	8.0	1.30	1.80	137	213	17	12	6.0	13.3	0.4	0.3	20	18	2
	105-110	7.9	1.36	1.95	173	213	17	13	7.5	13.3	0.4	0.4	21	20	3

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
87-OK-113	110-115	7.9	1.50	2.18	225	209	16	15	9.8	13.1	0.4	0.4	23	22	4
	115-120	8.0	1.34	1.93	241	131	14	10	10.5	8.2	0.4	0.3	19	19	5
	120-125	8.0	1.52	2.22	338	101	14	13	14.7	6.3	0.4	0.4	21	22	8
	125-130	8.1	1.63	2.57	443	74	14	28	19.3	4.6	0.4	0.8	24	26	13
	130-135	8.1	2.82	4.26	788	96	17	23	34.3	6.0	0.4	0.6	41	43	20
	135-140	8.0	3.33	5.00	936	127	21	22	40.7	7.9	0.5	0.6	49	50	20
	140-145	8.0	3.71	5.11	987	90	20	37	42.9	5.6	0.5	1.0	49	51	26
	145-150	7.6	4.35	5.93	1176	150	34	40	51.1	9.4	0.9	1.1	61	59	24
	150-155	7.9	4.16	5.54	1079	102	22	42	46.9	6.4	0.6	1.2	54	55	26
	155-160	7.7	4.16	5.83	1157	131	31	43	50.3	8.2	0.8	1.2	59	58	25
87-OK-114	0-2.5														
	2.5-5.0	8.1	4.73	7.27	694	883	12	66	30.2	55.2	0.3	1.9	86	73	6
	5.0-7.5	8.2	4.91	7.43	763	873	12	73	33.2	54.6	0.3	2.1	88	74	6
	7.5-10.0	8.3	4.19	6.13	686	661	15	69	29.8	41.3	0.4	1.9	72	61	7
	10.0-12.5	8.2	4.29	6.22	686	683	18	88	29.8	42.7	0.5	2.5	73	62	6
	12.5-15.0	8.2	1.51	2.28	268	178	12	48	11.7	11.1	0.3	1.4	23	23	5
	15.0-17.5	8.1	1.04	1.36	164	99	10	28	7.1	6.2	0.3	0.8	14	14	4
	17.5-20	8.0	1.28	1.77	167	169	12	27	7.3	10.6	0.3	0.8	18	18	3
	20-25	8.1	0.55	0.65	64	51	9	18	2.8	3.2	0.2	0.5	6	7	2
	25-30	8.0	0.70	0.93	40	145	13	8	1.7	9.1	0.3	0.2	11	9	1
	30-35														
	35-40	8.0	0.87	1.13	51	175	15	10	2.2	10.9	0.4	0.3	14	11	1
	40-45	7.9	0.76	0.97	39	154	13	8	1.7	9.6	0.3	0.2	12	10	1
	45-50	8.0	0.83	1.07	46	172	16	11	2.0	10.8	0.4	0.3	13	11	1
	50-55	8.1	0.79	1.04	53	155	14	9	2.3	9.7	0.4	0.3	12	10	1
	55-60	8.1	0.79	1.05	62	146	13	10	2.7	9.1	0.3	0.3	12	11	1
	60-65	8.1	0.84	1.11	73	151	12	9	3.2	9.4	0.3	0.3	13	11	1
	65-70	7.9	1.07	1.38	95	193	14	11	4.1	12.1	0.4	0.3	17	14	2
	70-75	7.9	1.31	1.83	137	224	15	10	6.0	14.0	0.4	0.3	20	18	2
	75-80	8.1	1.22	1.59	153	150	14	12	6.7	9.4	0.4	0.3	16	16	3
	80-85	8.0	1.50	2.06	220	183	16	17	9.6	11.4	0.4	0.5	21	21	4
	85-90	8.1	1.45	1.96	240	140	15	17	10.4	8.8	0.4	0.5	20	20	5
	90-95	7.9	1.53	2.19	301	141	14	25	13.1	8.8	0.4	0.7	22	22	6
	95-100	8.0	1.69	2.32	345	116	15	23	15.0	7.3	0.4	0.6	23	23	8
	100-105	8.0	1.73	2.61	432	85	13	20	18.8	5.3	0.3	0.6	24	26	12
	105-110	8.1	1.77	2.70	465	64	12	24	20.2	4.0	0.3	0.7	25	27	14
	110-115	7.8	4.13	5.79	1075	205	23	42	46.7	12.8	0.6	1.2	60	58	18
	115-120	7.9	4.57	6.12	1186	175	23	20	51.6	10.9	0.6	0.6	63	61	22
	120-125	7.8	4.47	6.32	1251	156	25	40	54.4	9.8	0.6	1.1	65	63	25
	125-130	7.8	4.62	6.54	1298	155	24	44	56.4	9.7	0.6	1.2	67	65	26
	130-135	7.7	3.28	6.17	1246	130	23	42	54.2	8.1	0.6	1.2	63	62	27
	135-140	7.8	4.40	6.31	1251	140	22	44	54.4	8.8	0.6	1.2	64	63	26
87-OK-115	0-2.5	8.4	1.45	1.74	152	181	14	14	6.6	11.3	0.4	0.4	18	17	3
	2.5-5.0	8.2	3.40	4.68	262	855	23	30	11.4	53.4	0.6	0.8	65	47	2
	5.0-7.5	8.1	3.36	4.70	267	841	23	29	11.6	52.6	0.6	0.8	65	47	2
	7.5-10.0	8.1	3.12	4.34	242	778	23	31	10.5	48.6	0.6	0.9	60	43	2
	10.0-12.5	8.0	2.92	3.98	208	719	26	27	9.0	44.9	0.7	0.8	55	40	2
	12.5-15.0	8.0	2.83	3.81	186	707	25	31	8.1	44.2	0.6	0.9	53	38	2
	15.0-17.5	8.0	2.57	3.71	214	654	27	35	9.3	40.9	0.7	1.0	51	37	2
	17.5-20	8.2	1.30	1.81	168	185	21	30	7.3	11.6	0.5	0.8	19	18	3
	20-25	8.2	1.30	1.84	160	210	23	31	7.0	13.1	0.6	0.9	21	18	3
	25-30	8.2	1.23	1.66	145	188	26	27	6.3	11.8	0.7	0.8	19	17	3
	30-35	8.1	1.35	1.78	135	225	23	21	5.9	14.1	0.6	0.6	21	18	2
	35-40	8.1	1.41	1.82	114	266	23	16	5.0	16.6	0.6	0.5	22	18	2
	40-45	8.1	1.27	1.74	81	286	24	15	3.5	17.9	0.6	0.4	22	17	1
	45-50	8.1	1.04	1.20	47	216	18	8	2.0	13.5	0.5	0.2	16	12	1
	50-55														
	55-60														
	60-65	8.0	1.37	1.79	68	295	30	14	3.0	18.4	0.8	0.4	22	18	1
	65-70	7.9	1.51	1.96	77	330	31	11	3.3	20.6	0.8	0.3	25	20	1
	70-75	7.9	1.95	2.63	114	472	36	16	5.0	29.5	0.9	0.5	35	26	1
	75-80	7.9	1.98	2.61	123	468	34	15	5.3	29.3	0.9	0.4	35	26	1
	80-85	7.9	1.89	2.30	123	376	33	19	5.3	23.5	0.8	0.5	30	23	2
	85-90	8.0	1.84	2.32	120	392	34	21	5.2	24.5	0.9	0.6	31	23	1
	90-95	7.9	1.69	1.98	76	354	32	8	3.3	22.1	0.8	0.2	26	20	1
	95-100														
	100-105	7.9	1.86	2.32	98	418	31	28	4.3	26.1	0.8	0.8	31	23	1
	105-110	7.9	1.66	2.10	82	376	31	22	3.6	23.5	0.8	0.6	28	21	1
	110-115	7.9	1.83	2.34	107	399	31	25	4.7	24.9	0.8	0.7	30	23	1
	115-120	7.8	1.96	2.51	127	420	33	28	5.5	26.3	0.8	0.8	33	25	2

Appendix D. Chemical analyses of soil samples from hydraulic rotary drilling (1:1 (soil:water) analyses)

Testhole No.	Depth (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						--------mg/L--------				-------meq/L-------			--meq/L--		
	120-125	7.8	2.02	2.56	158	400	31	17	6.9	25.0	0.8	0.5	33	26	2
	125-130	7.9	1.91	2.54	193	357	29	24	8.4	22.3	0.7	0.7	31	25	3
	130-135	8.0	1.70	2.22	187	240	29	26	8.1	15.0	0.7	0.7	24	22	3
	135-140	7.8	2.01	2.61	213	325	28	23	9.3	20.3	0.7	0.6	30	26	3
	140-145	8.0	1.78	2.23	193	249	26	23	8.4	15.6	0.7	0.6	25	22	3
	145-150	7.9	2.01	2.68	234	316	28	28	10.2	19.8	0.7	0.8	31	27	3
	150-155	7.9	1.88	2.56	232	289	25	24	10.1	18.1	0.6	0.7	29	26	3
	155-160	8.0	1.90	2.52	236	286	25	26	10.3	17.9	0.6	0.7	29	25	3
	160-165	8.0	1.93	2.52	236	297	24	21	10.3	18.6	0.6	0.6	29	25	3
	165-170	8.0	1.74	2.48	245	269	24	25	10.7	16.8	0.6	0.7	28	25	4
	170-175	8.0	1.85	2.54	244	299	23	28	10.6	18.7	0.6	0.8	30	25	3
	175-180	8.0	1.72	2.40	232	260	23	31	10.1	16.3	0.6	0.9	27	24	4
	180-185	8.0	1.87	2.47	236	297	22	21	10.3	18.6	0.6	0.6	29	25	3
	185-190	8.0	1.78	2.36	222	274	21	21	9.7	17.1	0.5	0.6	27	24	3
	190-195	8.1	1.63	2.10	213	212	19	17	9.3	13.3	0.5	0.5	23	21	4
	195-200	8.0	1.67	2.26	224	236	20	20	9.7	14.8	0.5	0.6	25	23	4
	200-205	8.0	1.57	2.12	214	218	20	23	9.3	13.6	0.5	0.6	23	21	4
	205-210	8.1	1.53	2.13	234	192	19	23	10.2	12.0	0.5	0.6	23	21	4
	210-215	8.1	1.50	2.14	230	203	17	23	10.0	12.7	0.4	0.6	23	21	4
	215-220	8.0	1.72	2.38	236	258	19	19	10.3	16.1	0.5	0.5	27	24	4
	220-225	8.1	1.51	2.10	226	198	17	22	9.8	12.4	0.4	0.6	23	21	4
	225-230	8.1	1.51	2.15	222	216	17	21	9.7	13.5	0.4	0.6	24	22	4
	230-235	8.1	1.52	2.11	213	213	17	19	9.3	13.3	0.4	0.5	23	21	4
	235-240	8.0	1.58	2.04	182	237	18	18	7.9	14.8	0.5	0.5	23	20	3
	240-245	8.0	1.64	2.07	164	261	20	17	7.1	16.3	0.5	0.5	24	21	2
	245-250	8.0	1.28	1.64	122	194	23	7	5.3	12.1	0.6	0.2	18	16	2
	250-255	8.1	0.97	1.15	98	132	20	5	4.3	8.3	0.5	0.1	13	12	2
	255-260	8.1	0.92	1.02	79	120	19	5	3.4	7.5	0.5	0.1	11	10	2
	260-265														
	265-270														
	270-275														
	275-280														
	280-285	7.6	3.10	3.92	350	559	25	20	15.2	34.9	0.6	0.6	51	39	4
	285-290	7.6	3.23	4.38	414	589	25	18	18.0	36.8	0.6	0.5	55	44	4

Depths with no chemical analyses indicate that no sample was obtained or sample consisted of sand and/or gravel only.

* Salt = E.C. extract * 10

APPENDIX E

Auger testhole logs

Appendix E. Auger Testhole logs

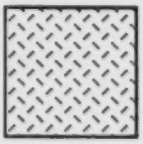
Testhole Log Symbol Key

gravel

sand

silt

clay



till

Cond. (dS/m @ 25C) - refers to the conductivity of a 1:1 (soil:water) suspension as measured with an immersion type conductivity probe

Texture - refers to manual hand estimation.

Est. Moist. - refers to the estimated moisture percentage done in the field.

Carb. - refers to the carbonate content of the soil. The estimation is done by determining the degree of effervescence when soil samples were exposed to HCL.

L0 - no carbonates
L1 - no visible bubbling, can only hear effervescence.
L2 - bubbling is barely visible.
L3 - visible bubbling.
L4 - violent bubbling.

EM-38 : vertical reading / horizontal reading

Y.S.I. - refers to conductivity reading of free water in the testhole measured with a portable conductivity meter

SITE: R Larson TESTHOLE: OK 1 DATE: April 27/87 LEGAL LOCATION: NW 15-36-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			6.58	7.9	loam	~20%	L1	-white salt ppts. in surface soils
Fine oxidized sand	1		7.82	8.2	fine sand	near sat.	L4	
			7.35	8.2				
			5.21	7.9	sandy clay-loam	saturated	L3	-oxidized till is floral-like (iron-stained) but is not very dense due to high moisture content
Oxidized till		5	4.90	8.0				
	2		5.01	7.9				-gypsum crystals at 7 feet to 10 feet depth
	3	10	4.58	7.9				
			4.81	7.8				
	4		4.43	7.8				-easy drilling to ~16 feet
	5	15	4.42	7.9				
Unoxidized till			3.08	8.4	clay loam	near sat.	L4	
	6	20						
	7		3.08	8.5				
	8	25	2.81	8.5				
	9	30						-difficult drilling and lost sample between 28 and 33 feet
Unoxidized fine sand	10		3.30	8.4	fine sand	saturated	L3	Free water at 33 feet.
		35						
Unoxidized till	11		2.16	8.6	clay	near sat.	L3	-till is extremely dense and has few stones
	12	40						
	13		2.05	8.5	clay	~15%	L3	-till appears to become drier with depth and stones are very small
	14	45	1.68	8.5				
	15	50						
	16		1.48	8.8				
	17	55			clay	~10%	L3	
	18		3.04	8.3				
	19	60						
			1.09	9.2				
	20	65						
	21		1.42	8.9				
		70						
	22		1.84	8.7	clay	~5%	L3	-till appears to become more shaley End of hole at 73 feet.
	23	75						

EM-38: 190/150

Y.S.I: 17.38 dS/m @25C

SITE: Larson TESTHOLE: OK 2 DATE: April 30/87 LEGAL LOCATION: SE 15-36-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			3.43	8.0	sandy loam	saturated	L4	
			3.17	8.1				-gypsum between 2 and 3 feet
	1		2.45	8.1			L3	
Oxidized sand		5	1.51	8.0	very fine	saturated	L2	
	2		0.73	8.2	sand			
Lacustrine (oxidized) clay			1.20	8.0	silty clay	saturated	L2	
	3	10	1.89	7.8				
Transitionally oxidized till	4				clay	saturated	L2	
			2.62	7.7				
	5	15						
Unoxidized till			2.59	7.9	clay	near sat.	L3	
	6	20						
			2.42	8.0				
	7				clay	near sat.	L3	
	8	25						
			1.12	8.4				
	9	30						
			1.09	8.4				
	10							
	11	35						
			1.27	8.3				End of hole at 38 feet.
	12	40						

Y.S.I: 2.58 dS/m @25C

SITE: Larson TESTHOLE: OK 3 DATE: May 1/87 LEGAL LOCATION: NW 16-36-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Dune sand			0.31	7.6	fine loamy	~5%	L0	
			0.22	8.2	sand	~8%	L4	
	1		0.12	8.6	fine sand		L2	
			0.28	8.5				
		5	0.25	8.6				
	2		0.20	8.8				
Transitionally oxidized lacustrine clay					silty clay	saturated	L2	
	3	10	0.58	8.1				
			0.58	7.9				
	4		0.42	8.0	clay	saturated	L2	-iron stains in till to about 19 feet
Transitionally oxidized till								
	5	15						
			0.40	8.0				Free water in hole at 18 feet.
					clay	saturated	L2	
	6	20						
Unoxidized till			1.84	7.6				
	7							
		25						
	8		1.46	7.7				-few iron stains in till at 28'
								End of hole at 28 feet.
	9	30						

EM-38: 15/10

Y.S.I: 1.41 dS/m @ 25C

SITE: Burke TESTHOLE: OK 4 DATE: May 1/87 LEGAL LOCATION: NW 8-26-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			1.34	8.0	loam	saturated	L3	
			1.59	7.8				
	1		1.20	7.9				
Fine oxidized sand		5	0.93	8.0	fine sand	saturated	L2	
	2		0.34	8.1				
Unoxidized lacustrine clay	3	10	0.49	8.5	clay	saturated	L2	
	4							
Unoxidized till	5	15	0.37	8.5	clay	saturated	L2	-few stones in the unoxidized till
	6	20						
	7							
	8	25						
	9	30						
	10				sand and gravel	saturated	L1	-pea size gravel
Unoxidized sand and fine gravel	11	35						
	12				sand and gravel	saturated	L1	
Oxidized sand and gravel		40						
	13		0.32	8.1				
	14	45						
	15	50						
	16							
		55						
Alluvium	17				vf sand and silt	saturated	L2	-consolidated very fine sand and silt
	18	60						
	19		0.39	8.7				
	20	65						
	21							End of hole at 68 feet.
		70						

EM-38: 75/78

Y.S.I: 0.94 dS/m @25C

SITE: Larson TESTHOLE: OK 5 DATE: May 1/87 LEGAL LOCATION: NW 15-36-29-8 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Lacustrine? Loess						loam-clay loam		L3	-many salt specs
Oxidized till	1		5			clay loam		L2	-till is highly oxidized with red ochre specs (Battleford-like) -much gypsum
Oxidized till	2					clay loam		L3	-till is jointed, stained, and highly oxidized
	3		10						End of hole at 11 feet.

EM-38: 230/230

SITE: Burke TESTHOLE: OK 6 DATE: May 4/87 LEGAL LOCATION: NE 7-26-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					sandy loam	dry		
	1				fine sand			
Oxidized sand and gravel		5						
	2							
	3	10			med. sand	~10%		
	4							
	5	15						
	6	20			coarse sand and gravel	saturated		
	7							
	8	25						
	9	30						-pea size gravel from ~30-35'
	10							
Unoxidized till	11	35			clay	saturated		
								End of hole at 38 feet.
	12	40						

EM-38: 15/13

Y.S.I: 0.37 dS/m @ 25C

SITE: Larson TESTHOLE: OK 7 DATE: May 4/87 LEGAL LOCATION: NW 13-36-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam	saturated	L2	
Oxidized sand	1	5			medium sand	saturated	L3	
	2							
	3	10			coarse sand	saturated	L2	
Unoxidized sand	4				coarse sand	saturated	L2	
	5	15						
Unoxidized lacustrine clay	6	20			silty clay	saturated	L1	End of hole at 18 feet.

Y.S.I: 0.42 dS/m @ 25C

SITE: Larson TESTHOLE: OK 8 DATE: May 4/87 LEGAL LOCATION: NE 13-36-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			1.64	9.6	sandy loam	saturated	L4	
	1		0.51	9.0	fine sand			
			0.56	8.9				
Oxidized sand		5	0.41	9.0				
	2				coarse sand	saturated	L3	
	3	10						
	4							
Unoxidized sand		15			coarse sand	saturted	L2	
	5							
	6	20						
Unoxidized till					clay	saturated	L2	
	7							
	8	25	0.32	8.7				
	9	30						
	10							
	11	35	0.36	8.7				
	12	40						
	13				medium to coarse sand	saturated	L2	
Unoxidized sand		45						
	14							
	15	50						
	16				clay	~10%	L2	-pieces of shale in the unoxidized till
Unoxidized till		55						
	17							
	18		0.53	9.0				
	19	60						
								End of hole at 63 feet.
	20	65						

EM-38: 45/42

Y.S.I: 0.43 dS/m @ 25C

SITE: B. Davison TESTHOLE: OK 9 DATE: May 4/87 LEGAL LOCATION: SW 5-3-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess	1	5	0.85 0.92 0.66 0.75	8.3 8.3 8.2 8.2	loam	saturated	L2	
Oxidized sand	2		0.86	8.2	med. sand	saturated	L3	
	3	10			coarse sand and gravel	saturated		Free water at 8 feet.
Oxidized lacustrine	4		3.00	7.9	very fine sand + silt	saturated	L2	
	5	15	3.60	7.8				
Transitionally oxidized till	6	20	3.22	7.8	clay	saturated	L2	-till has a distinct greenish color with few iron stains (Sutherland till?)
	7		2.75	7.8				
	8	25	2.83	7.7				
	9	30						
Shale	10		1.98	8.9	clay	dry	L0	-(bedrock) shale is highly disturbed and crumbly End of hole at 33 feet.
		35						

EM-38: 42/42

Y.S.I: 1.34 dS/m @25C

SITE: B. Davison TESTHOLE: OK 10 DATE: May 5/87 LEGAL LOCATION: SE 5-3-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			0.72	8.1	silty loam	near sat.	L3	-loess has few thin sandy interlayers
	1		0.65	8.5				
			0.61	8.7				
		5	0.73	8.8				
	2		0.57	8.7				
Oxidized sand					med. sand	~10%	L3	
	3	10	0.30	8.3				
	4		0.34	8.3		saturated	L2	-well sorted sand (black color) (organics?) from 14-15 feet
	5	15	0.76	8.1	clay	near sat.	L1	-till is a greenish color with few iron stains (Sutherland)
Transitionally oxidized till								End of hole at 18 feet.
	6	20						

EM-38: 22/15

SITE: B. Davison TESTHOLE: OK11 DATE: May 5/87 LEGAL LOCATION: SE 6-3-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			0.56	8.7	silty loam	~10%	L3	
			0.60	8.8				
	1		1.14	9.0				
Oxidized fine to medium sand		5			fine and med. sand	dry	L4	-well sorted sand
	2							
	3	10	0.25	8.8				-black (organics) in sand between 10 and 12 feet
	4							
	5	15						
Transitionally oxidized till					clay	near sat.	L2	-modified till (few stones)
	6	20	0.50	8.1				
	7							
	8	25	0.57	8.0	clay	saturated	L2	
Unoxidized sand					fine sand	saturated	L2	-high amount of clay in the sand
	9	30	0.43	8.2				
Unoxidized lacustrine clay					clay	saturated	L2	
	10							
	11	35	0.52	8.6				
	12	40						
	13							
	14	45						
Unoxidized shale	15				clay	near sat.	L0	-highly disturbed shale
	16	50						
	17	55				dry	L0	
								End of hole at 58 feet.
	18	60						

EM-38: 25/20

SITE: B. Davison TESTHOLE: OK 12 DATE: May 5/87 LEGAL LOCATION: SE 6-3-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silt loam	~15%		
Oxidized sand	1	5			fine to med sand	dry		
	2							
	3	10			gravel	dry		
	4				med. sand	dry		-black sand color between 12 and 26 feet
	5	15						
	6	20			med. sand	saturated		
	7							
	8	25						
	9	30						
	10							
	11	35						
	12	40						
Unoxidized lacustrine	13				silty clay	saturated	L2	
	14	45						
	15	50						
Unoxidized shale	16				clay	near sat.	L0	-bedrock shale is very disturbed
	17	55						
	18	60			clay	dry	L0	
	19							
	20	65						
	21							End of hole at 68 feet.
		70						

EM-38: 20/15

Y.S.I: 0.94 dS/m @ 25C

SITE: Burke TESTHOLE: OK 13 DATE: May 5/87 LEGAL LOCATION: NW 1-2-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam	dry	L4	
					fine sand	dry	L4	
	1							
Oxidized sand		5						
	2							
	3	10			med. sand	dry	L2	-sand is well sorted, clean and dry
	4							
		15						
	5							
	6	20			med. sand	saturated	L2	-no free water in the hole -sand is saturated at about 20 feet and collapses in the hole
	7							
		25						
	8							
	9	30						
	10							
		35						
	11							
	12	40			clay	saturated	L1	
Unoxidized till								
	13							
		45						
	14							
	15	50						
	16							End of hole at 53 feet.
		55						

EM-38: 22/20

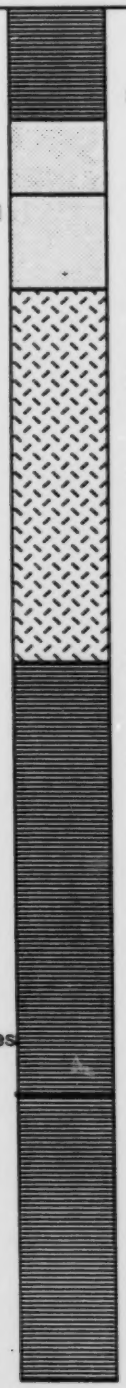
SITE: B. Davison TESTHOLE: OK 14 DATE: May 7/87 LEGAL LOCATION: SW 5-3-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			1.03	7.5	silt loam	saturated	L4	
			1.00	7.7				
	1		1.07	7.7				
Oxidized sand			1.16	7.7				
		5	1.38	7.9	med. sand	saturated	L3	-sand is dirty (clay present in sand) with interbeds of silts
	2		1.29	8.0				
Oxidized lacustrine					silty clay	saturated		
	3	10	2.74	8.0				
	4		2.00	8.1				
	5	15						-some iron stains in the till at the contact
Transitionally Oxidized till			2.39	7.9	clay	near sat.	L3	-Battleford-like till to 20'
	6	20	2.80	7.9				-Floral-like till at 20' (heavily iron stained)
Unoxidized shale	7		3.80	7.7	clay	dry		End of hole at 23 feet.
		25						

EM-38: 54/48

Y.S.I: 2.50 dS/m @ 25C

SITE: Burke TESTHOLE: OK 15 DATE: May 7/87 LEGAL LOCATION: SE 16-26-29-8 W3



Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Alluvium					silty clay	saturated	L4	
	1						L1	
		5			fine sand	saturated	L1	-very dirty (clayey) sand aquifer
Oxidized sand	2							
	3	10			fine sand	saturated	L4	
Unoxidized sand								
	4				coarse sand	saturated	L4	
		15						
	5				clay	saturated	L4	
Unoxidized till								
	6	20			clay	near sat.	L2	
	7							- interbedded sand lenses in the unoxidized till
	8	25						
	9	30						
	10							
	11	35			silty clay	saturated	L2	
Unoxidized lacustrine	12	40						
	13							
	14	45						
	15							
	16	50						
Unoxidized lacustrine with drop stones	17	55			silty clay	saturated	L2	-lacustrine has few pea size drop stones in the matrix between 53 and 58 feet
	18				silty clay	saturated	L2	
Unoxidized lacustrine	19	60						
	20	65						
	21							
	22	70						End of hole at 73 feet.
	23	75						

EM-38: 100/110

Y.S.I: 0.64 dS/m @ 25C

SITE: Konst TESTHOLE: OK 16 DATE: May 8/87 LEGAL LOCATION: SE 3-10-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			3.99	8.0	silt loam	saturated	L0	
			1.39	8.2				
	1		2.52	8.1	silt	saturated	L3	
		5	0.66	8.2				
	2		0.78	8.2				
Oxidized sand								Free water in hole at 8 feet.
	3	10	2.58	8.0	fine sand	saturated	L3	-sand aquifer is very dirty (clayey)
Oxidized Lacustrine	4		0.59	8.2	silty clay	saturated	L3	
	5	15	0.57	8.1				
Transitionally oxidized till					clay	near sat.	L2	-pieces of clay (shale) in the transitionally oxidized till
	6	20	1.90	7.9				-till is very dense at 20 feet
	7							
			2.61	7.8				
	8	25						
	9	30	2.49	7.9				
	10							
Unoxidized till		35	1.32	8.2	clay	~10%	L2	-great amount of iron staining at the unoxidized till contact
	11							
			1.77					
	12	40		8.3				-very dense till and difficult to penetrate with depth
	13		0.99	8.6				
		45						
	14		0.79	8.6				
	15	50						
	16		0.90	8.5				
		55						
	17		1.55	8.2				
	18	60						
	19		0.98	8.6				
	20	65	0.72	8.5				
	21							
		70						
	22		0.70	8.6				End of hole at 73 feet.
	23	75						

Y.S.I: 2.18 dS/m @25C

SITE: R. Larson TESTHOLE: OK 17 DATE: May 12/87 LEGAL LOCATION: SE 6-25-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			3.19	7.9	silty loam	~10%	L2	
Oxidized sand			1.57	8.4	fine to med. sand	~10%	L4	
	1		1.06	8.7				
Oxidized till		5	2.47	8.2	clay loam	~15%	L3	-oxidized till appears to be Floral till (iron stained)
			2.26	8.2				
	2							
			2.16	8.1	clay loam	~10%	L3	
	3	10						
	4		1.07	8.1				
		15						-oxidized till is turning unoxidized from 13-15 feet
	5				clay loam	~10%	L3	
Unoxidized till								
	6	20						
	7		0.64	8.5				
		25						-unoxidized till is very dense at 25 feet
	8							
	9	30						
	10		0.56	8.4				
		35						
	11							
			0.60	8.3				
	12							Free water in testhole at 39'.
Unoxidized sand		40	0.71	8.3	fine sand and med. grained sand	saturated	L3	
	13							
		45						
	14		0.65	8.4				
	15	50						
	16							
		55						
	17							
	18							
Unoxidized shale		60	0.61	8.4	clay	dry	L0	-shale is highly disturbed and is dificult to drill
	19							
	20	65						
	21							
		70	1.26	9.3				
	22							
								End of hole at 73 feet.
	23	75						

N.B. Static water level in open hole on May 14/87 is 2.90 m b.g.s.

EM-38: 50/55

Y.S.I: 0.92 dS/m @25C

SITE: R. Larson TESTHOLE: OK 18 DATE: May 13/87 LEGAL LOCATION: NW 5-25-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Alluvium			1.69	8.6	silty loam	saturated	L3	
			7.11	8.4				
	1		9.84	8.3				
Oxidized till		5	8.47	8.3	clay	near sat.	L3	-Battleford-like till at 3 feet
			5.24	8.0				
	2		5.49	8.0				
			6.09	7.8				
	3	10			clay	dry	LO	-shale is highly disturbed
Unoxidized shale			3.20	9.6				
	4							End of hole at 13 feet.
		15						

EM-38: 250/235

SITE: Fuglerud TESTHOLE: OK 19 DATE: May 13/87 LEGAL LOCATION: SE 4-26-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			4.22	8.1	silty loam	near sat.	L2	-white salt ppts in surface soils
			2.48	8.3				
	1		2.10	8.5				
Alluvium			3.34	8.0	sandy loam	saturated	L4	-very dirty sand aquifer
		5	2.96	8.1				-very thin sandy gravelly lense at 5 feet (very iron stained)
	2				clay loam	saturated	L2	-gypsum crystals at the
Oxidized till			2.32	8.1				oxidized till contact
	3	10	2.33	8.0		~10%	L2	
								-Battleford-like till from 6 to 9 feet and Floral-like till to
	4		1.78	8.0		~10%	L3	23 feet
		15						
	5							-some sand present in the joints of the Floral-like till
			1.92	7.8				
	6	20						
			0.95	8.1				
	7							End of hole at 23 feet.
		25						

EM-38: 78/80

SITE: Fuglerud TESTHOLE: OK 20 DATE: May 13/87 LEGAL LOCATION: SE 4-26-30-8 W3

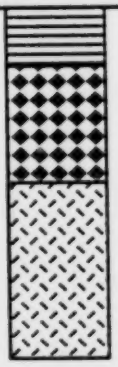
Geologic Material	meters	feet	Cond. dS/m @ 25 C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam	near sat.	L4	
Alluvium	1				fine sand	saturated	L2	
		5			silty loam	saturated	L2	
	2				fine sand	saturated	L2	
Oxidized sand and gravel					med. sand	saturated	L2	
	3	10			gravel	saturated	L2	
Oxidized till	4				clay	saturated	L2	End of hole at 13 feet.
		15						

EM-38: 22/15

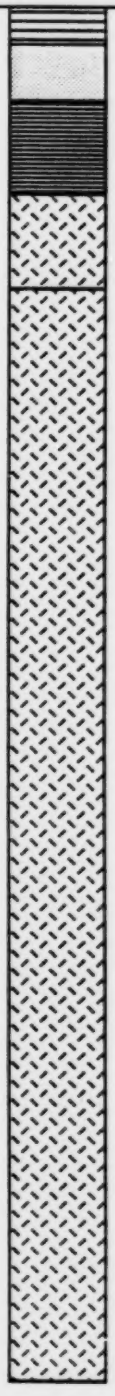
Y.S.I: 4.36 dS/m @25C

SITE: Fugelrud TESTHOLE: OK 21 DATE: May 13/87 LEGAL LOCATION: SE 3-26-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam	dry	L4	
Oxidized sand and gravel	1	5			coarse sand gravel	dry	L2	-sand and gravel are very iron stained
	2							
Oxidized till	3	10			clay till	~10%	L3	-oxidized till has gravel interbeds
	4							
	5	15						End of hole at 18 feet.
		20						



SITE: M. Larson TESTHOLE: OK 22 DATE: May 13/87 LEGAL LOCATION: SE-2-25-30-8 W3



Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			2.22	7.6	silt loam	saturated	L4	
			2.32	7.8				
Alluvium	1		1.28	8.3	fine sand	saturated	L3	
			1.71	8.2				
Lacustrine (oxidized)		5			silty clay	saturated	L2	
	2		2.87	7.9				
	3	10			clay	saturated	L2	-few stones in the oxidized till and some iron staining present
Oxidized till	4		3.42	7.9				
	5	15			clay	near sat.	L2	-transitionally oxidized till from 15 to 29 feet
Unoxidized till	6	20	3.11	7.9				
	7							
	8	25						
	9	30	2.17	7.9				
	10							-spun auger from 33 to 73 feet
	11	35						
	12	40						
	13							
	14	45						
	15	50						
	16							
	17	55						
	18							
	19	60						
	20	65						
	21							
	22	70						End of hole at 73 feet.
	23	75						

N.B. Static water level on May 14/87 in open hole is 1.5 m b.g.s..

EM-38: 92/92

Y.S.I: 6.37 dS/m @25C

SITE: Larson TESTHOLE: OK 23 DATE: May 14/87 LEGAL LOCATION: SW 6-25-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam	~10%	L4	
Oxidized sand	1	5			silty fine sand	~5%	L4	
	2							
	3	10						
Oxidized dune sand	4				medium grained sand	saturated	L2	-sand is saturated at 12 feet
Transitionally oxidized till	5	15			clay	saturated	L2	-till is Floral-like between 14 and 16 feet -till begins to turn unoxidized at 18 feet End of hole at 18 feet.
	6	20						

EM-38: 19/13

Y.S.I: 3.36 dS/m @ 25C

SITE: M. Larson TESTHOLE: OK 24 DATE: May 14/87 LEGAL LOCATION: SE 6-25-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam fine sand	~5%	L4 L4	
Oxidized fine sand	1	5			loamy sand	near sat.	L4	-organics in the sand at 5 feet depth
Oxidized till	2				clay	near sat.	L3	
	3	10						-no free water in the hole
	4							End of hole at 13 feet.
		15						

EM-38: 19/12

SITE: Larson TESTHOLE: OK 25 DATE: May 14/87 LEGAL LOCATION: SE 7-25-30-8 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess						fine sandy loam	~15%	L4	-Battleford-like till from 2-7'
Oxidized till	1		5			sandy loam	saturated	L4	
	2					sandy clay loam	saturated	L4	-gypsum present at 7 feet -Floral-like till from 7-8 feet End of hole at 8 feet.
	3		10						

EM-38: 42/35

SITE: Larson TESTHOLE: OK 26 DATE: May 14/87 LEGAL LOCATION: NE 2-25-30-8 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess						silty loam	dry	L1	
Oxidized sand						silty sand	~5%	L4	
Oxidized till			5			clay loam	~5%	L4	
	2								End of hole at 8 feet.
	3		10						

EM-38: 36/34

SITE: Fuglerud TESTHOLE: OK 27 DATE: May 14/87 LEGAL LOCATION: SW 1-26-30-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess	1				silt silty sand	dry ~10%	L3 L4	
Oxidized sand and gravel	2	5			coarse sand and gravel	dry	L4	
Oxidized till	3	10			clay	saturated saturated	L3	-saturated gravel at 9 feet -Floral-like till at 10 feet -till is quite dense
	4	15						End of hole at 13 feet.

EM-38: 23/14

SITE: L. Erlandson TESTHOLE: OK 28 DATE: May 19/87 LEGAL LOCATION: SW 3-29-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			1.61	7.6	loam	~5%	L0	
			2.99	8.0	silt		L4	-high amount of carbonates
	1		2.56	8.1	silty loam	saturated	L3	between 1 and 2 feet
Oxidized lacustrine (alluvium?)		5	2.11	7.9			L2	-gypsum at 2 feet
	2		0.67	8.0				
	3	10	0.65	7.8	clay	saturated	L2	
			0.91	7.7				
Unoxidized till	4				clay	saturated	L2	-some oxidized streaks in the largely unoxidized Battleford-like till
	5	15	0.81	7.8				-very few stones in the till
					clay	near sat.	L2	
	6	20	1.76	7.6				
	7		1.94	7.7				
	8	25						End of hole at 26 feet.
		30						

N.B. static water level in the open hole on May 21/87 was 2.30m b.g.s..

EM-38: 70/63

Y.S.I: 1.22 dS/m @ 25C

SITE: M. Larson TESTHOLE: OK 29 DATE: May 19/87 LEGAL LOCATION: SW 2-30-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			3.98	7.6	loam	~10%	L0	
			5.63	8.0	silt loam		L4	
	1		5.48	8.1	med. sand	near sat.	L2	
Oxidized sand			3.90	8.3				
		5	3.54	8.0				
Oxidized lacustrine	2				silty clay	saturated	L2	
			3.83	7.9				
Oxidized till					clay	saturated	L2	-gypsum at 8 ' (till contact)
	3	10						
			2.60	7.8				
	4				clay	near sat.	L2	-few oxidized streaks in the unoxidized till for the first 5-8 feet
Unoxidized till		15						
	5		1.87	7.7				
	6	20						
	7							-easy drilling between 23 and 28 feet. Unoxidized till is nearly saturated.
	8	25						
								-difficult drilling from 28 to 40 feet
	9	30						
	10							
	11	35						
	12							-easier drilling between 40 and 70 feet
		40						
	13							
	14	45						
	15							
		50						
	16							
	17	55						
	18							
		60						
	19							
	20	65						
	21							
		70						End of hole at 70 feet.

N.B. Static water level on May 15/87:
15'P - 2.84m
30'P - dry
50'P - 12.77m
70'P - 19.09m

EM-38:120/140

Y.S.I: 7.03 dS/m @ 25C

SITE: M. Larson TESTHOLE: OK 30 DATE: May 19/87 LEGAL LOCATION: SW 2-30-30-7 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess						loam	~5%	L0	
Oxidized sand						med. sand	~8%	L1	
Oxidized lacustrine	1					silty clay	saturated	L1	
Oxidized sand			5			med sand	saturated	L1	
Oxidized till	2					clay	saturated	L1	-small and few stones in the Battleford-like till End of hole at 8 feet.
	3		10						

EM-38: 35/30

SITE: H. Henricks TESTHOLE: OK 31 DATE: May 19/87 LEGAL LOCATION: SW 4-16-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			2.38	8.2	loam	~5%	L0	-white salt precipitates in the surface topsoil
			0.87	8.2				
	1		0.97	8.3	silty sand	saturated	L4	
Oxidized sand			1.27	8.3	and gravel			
		5	0.82	8.3				
	2		0.38	8.4				
Oxidized lacustrine	3	10	0.54	8.0	silt clay	saturated saturated	L1 L2	
	4		0.31	8.7	clay	saturated	L3	-carbonate pockets in the till between 17 and 18 feet
Unoxidized till		15						
	5		0.31	8.6				End of hole at 18 feet.
		20						

EM-38: 42/62

Y.S.I: 1.22 dS/m @ 25C

SITE: E. Carlson TESTHOLE: OK 32 DATE: May 19/87 LEGAL LOCATION: SE 4-15-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess and colluvium	1				silt loam	~10%	L0	
Oxidized sand	2	5			fine sand	saturated	L0	
					med. sand	saturated	L0	
Oxidized lacustrine	3	10			silty clay	saturated	L0	
Unoxidized lacustrine	4				silty clay	saturated	L0	
	5	15			med. sand	saturated	L0	
Unoxidized sand	6							
	7	20						
	8							
	9	25						
Unoxidized lacustrine	10				clay	saturated	L1	
	11	30						
	12							
Unoxidized till	13	35			clay	saturated	L1	- very few stones in the unoxidized till
	14							-unoxidized till is very soft
	15	40						
	16							
	17	45						End of hole at 58 feet.
	18							
		50						
		55						
		60						

EM-38: 22/12

Y.S.I: 0.21 dS/m @ 25C

SITE: E. Carlson TESTHOLE: OK 33 DATE: May 20/87 LEGAL LOCATION: SE 4-15-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam fine sand	~5% dry	L0 L1	-sand is very well sorted and clean
Oxidized sand	1	5						
	2							
	3	10						
	4							
	5	15			silty sand	saturated	L1	
	6	20						
Unoxidized sand	7				fine sand and silt	saturated	L1	-sand layer is very dirty with silt
	8	25						
	9	30						
Unoxidized lacustrine	10				silty clay	saturated	L2	-carbonate pockets in the lacustrine clay
	11	35						
	12	40						
	13							
	14	45						
	15	50						
	16							
	17	55						
	18							
Unoxidized till		60			clay	saturated	L2	-till is very soft and has very few stones
	19							
	20	65						
	21							End of hole at 68 feet.
		70						

EM-38: 11/6

SITE: M. Larson TESTHOLE: OK 34 DATE: May 21/87 LEGAL LOCATION: NW 2-30-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					sandy loam	dry	L0	
Oxidized sand	1				fine sand	dry	L4	
		5						
Unoxidized lacustrine	2				clay	~10%	L2	-lacustrine clay is varved
Oxidized till	3	10			clay	~10%	L2	-Battleford-like till at 8 feet
	4							End of hole at 13 feet
		15						

EM-38: 24/15

SITE: L. Dahl TESTHOLE: OK 35 DATE: May 21/87 LEGAL LOCATION: SE 9-21-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam	~10%	L2	
Alluvium 1					sandy silt	saturated	L4	
Oxidized sand 2		5			v.f. sandy silt	saturated	L2	
Oxidized gravel 3		10			gravel	saturated	L2	
Oxidized till 4					clay loam	saturated	L1	-till is iron stained and resembles Floral-like till End of hole at 13 feet.
		15						

N.B. May 24/87 static water level is 2.15m b.g.s..

EM-38: 46/58

Y.S.I: 1.06 dS/m @ 25C

SITE: M. Larson TESTHOLE: OK 36 DATE: May 25/87 LEGAL LOCATION: SW 2-30-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			3.11	7.7	sandy loam	~15%	L2	
			1.81	7.7				
	1		0.63	8.0				
Oxidized sand		5	1.19	7.8	fine sand	saturated	L2	
	2				coarse sand	saturated	L2	
Oxidized lacustrine					silty clay	saturated	L3	
	3	10	0.53	8.1				
	4				clay	saturated	L1	
Oxidized till								-difficult drilling between 15 and 18 feet.
	5	15	0.37	8.0				
								End of hole at 18 feet.
	6	20						

EM-38: 41/40

SITE: M. Larson TESTHOLE: OK 37 DATE: May 25/87 LEGAL LOCATION: SW 2-30-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			2.78	7.5	sandy loam	~5%	L0	
			2.62	8.2			L4	
	1		2.80	8.2	fine sand	~5%	L2	
Oxidized sand		5	2.00	8.2				
					silty clay	saturated	L3	-gypsum at 5 feet
Oxidized lacustrine	2		3.54	7.8				
	3	10			clay	near sat.		
Oxidized till			2.40	7.8			L2	-no free water in the hole End of hole at 13 feet.
	4							
		15						

EM-38: 55/45

SITE: M. Larson TESTHOLE: OK 38 DATE: May 25/87 LEGAL LOCATION: SW 2-30-30-7 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess				1.61 1.48 1.15	7.6 7.6 7.8	loam	~5%	L0 L4	
	1								
Oxidized lacustrine			5	1.09 1.14	7.8 7.8	silty clay-loam	saturated	L3	
Oxidized till	2			1.48	7.9	clay	saturated	L2	-no free water in hole -Battleford-like till End of hole at 8 feet.
	3		10						

EM-38: 62/52

SITE: M. Larson TESTHOLE: OK 39 DATE: May 25/87 LEGAL LOCATION: SW 2-30-30-7 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess				3.75	7.9	silt loam	near sat.	L0	
Oxidized sand				4.57	8.1			L2	
	1			5.85	8.0	silty sand	saturated	L4	-no free water in the hole
Oxidized lacustrine			5	6.25	7.8	silty clay	saturated	L4	-gypsum in the oxidized lacustrine
Oxidized till	2			2.80	7.8	clay	saturated	L3 L2	-Battleford-like till End of hole at 8 feet.
	3		10						

EM-38: 135/130

SITE: E. Carlson TESTHOLE: OK 40 DATE: May 26/87 LEGAL LOCATION: NW 5-15-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam fine sand	~5% dry	L0 L4	
Oxidized sand	1	5						
	2				med. sand	saturated	L3	-dark organic? stains in the sand at 8 feet
	3	10			gravel	saturated		-some gravel mixed in the sand at 11 feet depth
	4							
	5	15			med. sand	saturated		
	6	20						-no free water in hole (sand collapsed)
	7							-dark organic stains at 22'
	8	25						
Unoxidized lacustrine					silt and silty clay	saturated	L2	
	9	30						
	10							
	11	35						
	12							
		40			silty clay	saturated	L2	
	13							
	14	45						
	15							
	16	50						
Unoxidized till	17	55			clay	saturated	L2	
	18							End of hole at 58 feet.
		60						

EM-38: 7/5

SITE: L. Dahl TESTHOLE: OK 41 DATE: May 26/87 LEGAL LOCATION: NW 5-22-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25 C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silt	dry	L1 L4	
Oxidized sand1					fine sand	dry	L3	
Oxidized gravel		5			coarse gravel	dry	L2	-pea size gravel and larger egg sized rocks
	2							
	3	10						
	4							
	5	15						
	6	20			fine and coarse gravel	saturated	L2	-no free water, sand collapsed
	7							
	8	25						
Unoxidized till	9	30			clay	saturated	L2	-pieces of shale in the unoxidized till
	10							End of hole at 33 feet.
		35						

EM-38: 4/0

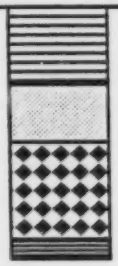
SITE: L. Dahl TESTHOLE: OK 42 DATE: May26/87 LEGAL LOCATION: SW 9-21-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silt	~5%	L4	
Oxidized sand	1				fine sand	~5%	L3	
Oxidized gravel		5			med. gravel	saturated	L3	- pea sized gravel is very clean and would be good to complete a water well in
	2							
	3	10						
	4							
	5	15						
Unoxidized lacustrine					clay	saturated	L2	-no free water in hole due to the sand collapse
	6	20				saturated	L2	
Unoxidized till					clay			
	7							End of hole at 23 feet.
		25						

EM-38: 65/60

SITE: L. Dahl TESTHOLE: OK 43 DATE: May 26/87 LEGAL LOCATION: SE 9-21-31-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess	1				silty loam	saturated	L4	
Oxidized sand	2	5			silty sand	saturated	L3	
Oxidized gravel	3	10			coarse gravel	saturated	L2	-large amount of silt present in the gravel
Unoxidized lacustrine	4				clay	saturated	L2	-unoxidized lacustrine is grading into till End of hole at 13 feet.
		15						



EM-38: 55/80

SITE: P.F.R.A. TESTHOLE: OK 44 DATE: June 3/87 LEGAL LOCATION: SW 4-15-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			4.60	8.0	silty loam	~15%	L2	
			3.52	8.2		near sat.	L4	
	1		3.73	8.2				
			5.19	8.1	f.s. loam	saturated	L3	-dry hole
		5	6.79	8.0				
			6.65	7.9	clay loam	saturated	L3	-gypsum at 6 feet
Oxidized till	2		6.08	7.9	clay	saturated	L3	-Battleford-like till at 7 feet End of hole at 8 feet.
	3	10						

SITE: P.F.R.A. TESTHOLE: OK45 DATE: June 3/87 LEGAL LOCATION: SW 4-15-29-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			3.35	8.3	silty loam	dry	L2	
			1.47	8.1			L3	
	1		0.50	7.6				-dry hole
			0.53	7.6	loam	saturated	L3	
		5	0.77	7.6			L4	-loaded with CaCO3 from 5 to 7 feet
	2		0.67	7.9				
Oxidized till			0.48	8.0	clay loam	saturated	L4	End of hole at 8 feet.
	3	10						

N.B. Testhole located over an old dump site

SITE: R. Mcpherson TESTHOLE: OK 46 DATE: June 4/87 LEGAL LOCATION: SW 4-5-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			7.19	8.2	loam	~10%	L0	
			5.28	8.5				
	1		6.99	8.6	sandy loam	~15%	L4	
Oxidized lacustrine		5	8.35	8.4	clay	near sat.	L3	
					clay	saturated	L2	-varving in lucustrine clay
	2							
			9.02	8.1				
	3	10						
Transitionally oxidized till					clay	saturated	L2	-Floral-like till (very dense)
	4		6.01	8.1				
		15						
	5		7.22	8.1				
Oxidized sand					fine to med. sand	saturated	L2	
	6	20						
					clay	saturated	L2	-fractures in oxidized till
Unoxidized till	7		5.50	8.5				
		25						
	8		3.82	8.3				
								End of hole at 28 feet.
	9	30						

EM-38: 240/200

Y.S.I: 22.32 dS/m @ 25C

SITE: A. Duncan TESTHOLE: OK 47 DATE: June 4/87 LEGAL LOCATION: SW 4-3-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			9.30	8.0	loam	near sat.	L2	-gypsum at 2 feet
			11.45	8.1				
	1		10.76	8.0				
Oxidized till		5			clay	saturated	L3	-Floral-like till at 5 feet
	2		4.21	8.0				
					clay	saturated	L3	
	3	10						
			5.64	7.7				
	4							
		15	6.34	7.6				
	5							
Oxidized shale								-dry hole
					clay	~15%	L0	-shale is brecciated and disturbed
	6	20	4.84	7.3				
	7		2.56	9.0	clay	~10%	L0	-easy to drill from 22 to 28'
Unoxidized shale		25						
	8		2.55	9.5				
								-Bentonitic seam in shale from 27 to 28 feet
	9	30						
	10							
		35						
	11							
	12	40						-difficult drilling to 63 feet
	13							
		45						
	14							
	15	50						
	16							
		55						
	17							
	18	60						
	19							End of hole at 63 feet.
		65						

EM-38: 310/310

SITE: M. Kasper TESTHOLE: OK 48 DATE: June 4/87 LEGAL LOCATION: NW 5-14-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand					fine sand	dry	L0	-sand is well sorted and clean
	1	5						-no rocks in sand
	2							
Oxidized lacustrine	3	10			silty sand	saturated	L3	
					silt	saturated	L3	
	4							
	5	15						
	6	20						
Unoxidized lacustrine					silty clay	saturated	L2	
	7							
	8	25						
	9	30						
	10							-fine sandy interbeds from 32 to 33 feet
Oxidized till	11	35			clay	saturated	L3	
	12							End of hole at 38 feet.
		40						

EM-38: 14/5

Y.S.I: 1.16 dS/m @ 25C

SITE: A. Kubashek TESTHOLE: OK 49 DATE: June 4/87 LEGAL LOCATION: NW 13-11-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam	~20%	L2	
					silt	saturated	L4	
	1				silty clay	saturated	L2	
Oxidized lacustrine		5						
	2							
	3	10			silty clay	saturated	L2	
	4							
	5	15						
	6	20			silty clay	saturated	L2	-interbedded sand in the silty clay from 20 to 25 feet
	7							
	8	25						
	9	30						
Unoxidized till					clay	saturated	L2	
	10							End of hole at 33 feet.
		35						

EM-38: 100/150

Y.S.I: 2.36 dS/m @ 25C

SITE: Crown land TESTHOLE: OK 50 DATE: June 5/87 LEGAL LOCATION: NW 4-2-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam	~20%	L4	
Oxidized lacustrine	1	5			loam silty clay	saturated saturated	L4 L3	-buried soil from 2 to 3 feet
	2							
	3	10			clay	saturated	L2	
	4							-interbedded medium sand from 11 to 16 feet -free water in the hole at 13'
Oxidized till	5	15			clay	saturated	L2	
	6	20						
	7							
	8	25						
	9	30						
Unoxidized shale	10				clay	~15%	LO	-shale is brecciated and partially oxidized in the fractures
	11	35						
	12							End of hole at 38 feet.
		40						
	13							

EM-38: 150/150

Y.S.I: 3.61 dS/m @ 25C

SITE: J. Kasper TESTHOLE: OK 51 DATE: June 5/87 LEGAL LOCATION: NE 15-16-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silt loam	near sat.	L0 L3	
Oxidized sand	1				f.s. loam	saturated	L2	
Oxidized lacustrine	2	5			silty clay	saturated	L1	
	3	10						-dry hole
Oxidized till	4				clay	saturated	L1	-Floral-like till from 12 to 15 feet -interbedded fine sand from 12 to 15 feet
Unoxidized till	5	15			clay	saturated	L1	
		20						End of hole at 18 feet.

EM-38: 160/140

SITE: K. Carlson TESTHOLE: OK 52 DATE: June 5/87 LEGAL LOCATION: SW 2-27-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					silty loam	near sat.	L4	
Oxidized lacustrine	1				silty loam	saturated	L3	-interbedded fine sand in lacustrine from 2 to 3 feet
		5						
	2							
	3	10			silt	saturated	L3	
	4							
	5	15						-lacustrine is very soft
							L2	
	6	20						
	7							
	8	25			silty loam	saturated	L2	-interbedded sand stringers at random intervals from 25 to 42 feet
	9	30						
	10							
	11	35						
	12							
		40			clay	saturated	L2	
Unoxidized lacustrine	13				clay	saturated	L2	
		45						
	14							
Unoxidized till	15	50			clay	saturated	L2	
	16							
		55						
	17							
								End of hole at 58 feet.
	18							
		60						

EM-38: 150/170

Y.S.I: 4.48 dS/m @ 25C

SITE: K. Carlson TESTHOLE: OK 53 DATE: June 9/87 LEGAL LOCATION: SE 4-27-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam	near sat.	L4	-fine sandy interbeds from 1 to 2 feet
Oxidized lacustrine	1	5			silt loam	saturated	L4	-gypsum at 3 feet
	2							
	3	10			silt	saturated	L3	
	4							
	5	15			silty clay	saturated	L2	-fine sandy interbeds from 13 to 18 feet
Unoxidized lacustrine	6	20						
	7							
	8	25						
	9	30			clay	saturated	L2	
	10							
	11	35						
	12	40			clay	saturated	L2	
Unoxidized till	13							
	14	45						
	15	50						End of hole at 48 feet.

EM-38: 150/150

Y.S.I: 4.31 dS/m @ 25C

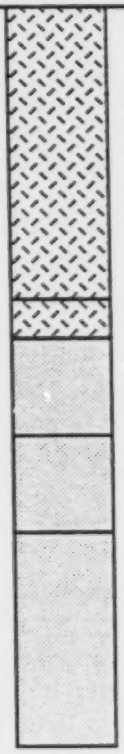
SITE: A. Larson TESTHOLE: OK 54 DATE: June 9/87 LEGAL LOCATION: NE 9-26-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam	near sat.	L3	-loaded with salt ppts. in top 1 foot
Oxidized lacustrine	1	5			silty loam			-gypsum at 2 feet
	2				silty loam	saturated	L2	
	3	10						-lacustrine very soft and sticky
	4							
	5	15			silty loam	saturated	L2	
	6	20				saturated	L2	
Unoxidized lacustrine	7				silty loam			End of hole at 23 feet.
		25						

EM-38: 80/70

Y.S.I: 0.97 dS/m @ 25C

SITE: S. Tomasiewicz TESTHOLE: OK 55 DATE: June 9/87 LEGAL LOCATION: NW 7-28-28-7 W3



Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized till			3.05	7.8	loam	dry	L2	
			7.64	8.2				
	1		6.70	8.2				-gypsum from 3 to 4 feet
		5	6.39	8.1	sandy clay loam	saturated	L2	-Battleford-like till
	2							
	3	10	2.71	7.9				
					sandy clay loam	saturated	L2	-Floral-like till at 12 feet
	4							
Unoxidized till		15	1.41	7.9	sandy clay loam	saturated	L1	
	5							
Oxidized sand								
	6	20	2.02	7.7	loamy sand	saturated	L1	-possibly Empress sand
Oxidized bedrock sand	7				fine sand	near sat.	L0	-sand is highly consolidated than sand above
		25	0.47	7.6				
	8							
Unoxidized bedrock sand					fine sand	near sat.	L0	-unoxidized sand is also consolidated and well sorted
	9	30						
			0.52	8.9				
	10							
		35						
	11							
								End of hole at 38 feet.
	12							
		40						

EM-38: 250/240

SITE: S. Tomasiewicz TESTHOLE: OK 56 DATE: June 11/87 LEGAL LOCATION: NE 6-28-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			8.93	7.8	clay loam	near sat.	L1	
			2.55	8.3				
Oxidized lacustrine	1		2.12	8.3	sandy loam	saturated	L4	
		5	5.03	8.0	clay loam	saturated	L2	-gypsum from 4 to 5 feet
Oxidized till	2		4.32	8.0	clay	saturated	L3	-Battleford-like till
	3	10						
	4		3.56	7.9				
Transitionally oxidized till	5	15	3.28	7.9	clay	saturated	L3	-Floral-like till at 14 feet -sandy interbeds between 17 and 18 feet -free water in the hole at 18'
Unoxidized till	6	20	0.98	8.5	clay	saturated	L3	
	7							
	8	25	1.08	8.5				
Unoxidized shale	9	30	1.03	9.2	clay and sand stringers	~10%	L0	
	10							End of hole at 33 feet.
		35						

EM-38: 290/300

Y.S.I: 10.98 dS/m @ 25C

SITE: S. Tomasiewicz TESTHOLE: OK 57 DATE: June 11/87 LEGAL LOCATION: NW 2-28-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					clay loam	saturated	L4	
	1				clay	saturated	L4	
Oxidized lacustrine		5						-gypsum from 5 to 6 feet
	2							
	3	10			clay	saturated	L2	
Oxidized till								
	4							-water slurry in hole at 13' -sand stringers from 13 to 15 feet
Oxidized bedrock sand	5	15						
Unoxidized bedrock sand								End of hole at 18 feet.
		20						

EM-38: 250/240

SITE: G. Martyn TESTHOLE: OK 58 DATE: June 12/87 LEGAL LOCATION: SE 4-33-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			11.69	8.4	loam	saturated	L2	
			4.98	8.1				
	1		3.77	8.3	clay loam	saturated	L4	
Oxidized lacustrine		5	5.46	8.0				-gypsum from 4 to 5 feet
	2		3.80	7.9				
	3	10			clay	saturated	L3	-sand stringers from 9 to 20' -free water in hole at 9 feet
Oxidized till	4							
			1.75	7.9				
	5	15						
	6	20						
			1.67	8.0				-pieces of shale in till from 20 to 25 feet
	7							-sand stringers from 23 to 25 feet (Empress group?)
		25			clay			
Unoxidized shale	8		4.21	7.4		near sat.	L0	-oxidized streaks in the shale
								End of hole at 28 feet.
		30						

EM-38: 220/260

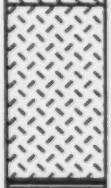
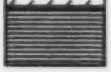
Y.S.I: 7.53 dS/m @ 25C

SITE: L. Ivan TESTHOLE: OK 59 DATE: June 12/87 LEGAL LOCATION: NW 12-7-28-6 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized till			7.82	7.9	clay	near sat.	L0	-salt ppts. in surface soil
			3.41	8.1			L4	
	1		2.06	8.1				-great amount of shale in the oxidized till
		5	3.37	7.9		saturated	L2	
	2		2.86	7.9				-few iron stains in till
Unoxidized shale					clay	~15%	L0	
	3	10	3.16	6.8				-selenite crystals in bedrock shale
	4							End of hole at 13 feet.
		15						

EM-38: 190/210

SITE: L. Ivan TESTHOLE: OK 60 DATE: June 15/87 LEGAL LOCATION: NE 12-7-28-6 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized till	1		5			clay loam	dry	L0 L4 L2	-Battleford-like till from 0-6 feet
Unoxidized till	2 3 4		10			clay	dry	L3	-shale in till from 6-15 feet -Floral-like till at 6 feet
Unoxidized shale	5		15			clay	dry	L0	-shale is crumbly and has iron stains End of hole at 18 feet.
			20						

EM-38: 55/40

SITE: W. Tomecek TESTHOLE: OK 61 DATE: June 16/87 LEGAL LOCATION: SW 3-5-29-6 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			7.17	7.9	loam	~20%	L2	
Oxidized alluvium	1		8.11	8.2	clay loam	saturated	L4	-gypsum at 2 feet
			8.48	8.2				
			9.03	8.2				
Oxidized sand		5	8.71	8.0				
	2		7.85	8.2	fine sand	saturated	L2	
Oxidized till			6.10	8.1	clay	saturated	L4	-Battleford-like till
Transitional oxidized till	3	10	6.87	8.0	clay	near sat.	L2	-Floral-like till
	4		5.72	7.8	fine sand	saturated	L4	
Oxidized till		15	5.49	8.1				
	5				clay	near sat.	L4	-dense till between 16 and 40 feet
Unoxidized till			4.58	8.0				-free water at 18 feet
	6	20						
	7							
	8	25	3.86	7.9				
	9	30			clay	near sat.	L3	
	10							-pieces of shale in the till matrix
	11	35	1.65	8.4				
	12	40						
Unoxidized sand			2.65	7.9	fine sand	saturated	L2	
	13							
	14	45			clay	near sat.	L2	-till is very fractured and is easy to penetrate
Unoxidized till								-spun the auger from 45 to 73'
	15	50						
	16							
	17	55						
	18							
	19	60						
	20							
	21	65						
	22	70						End of hole at 73 feet.
	23	75						

EM-38: 310/300

Y.S.I: 16.80 dS/m @ 25C

SITE: Ed Peters TESTHOLE: OK 62 DATE: June 18/87 LEGAL LOCATION: NW 14-24-30-6 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			2.41	7.5	loam	~15%	L0	
Alluvium			6.54	8.4	f.s. loam	saturated	L4	
	1		5.96	8.5			L1	
Oxidized till		5	7.28	8.0	clay			-pieces of shale in till
	2		4.90	7.9				-Floral-like till
	3	10	4.83	7.8				
Unoxidized till	4				clay			
	5	15	2.99	8.2				-some iroin stains in unoxidized till to ~22 feet
	6	20	1.78	8.6				
	7							
	8	25						
Unoxidized sand			1.71	8.5	fine sand	saturated	L3	-sand is dirty
	9	30						
Unoxidized till			1.63	8.3	clay	saturated	L3	
	10				clay	~15%	L1	
Unoxidized lacustrine		35						
	11		3.53	8.3				
	12	40						
	13							
	14	45						
								-clay is slicken sided from 48 to 73 feet
	15	50	3.39	8.2	clay	~15%	L1	-clay is dense but breaks into pieces when drilled
	16							
	17	55						
	18							
	19	60						
	20	65	2.56					
	21			8.3				
		70						
	22							End of hole at 73 feet.
	23	75						

EM-38: 260/260

Y.S.I: 15.52 dS/m @ 25C

SITE: W. Arthur TESTHOLE: OK 63 DATE: June 18/87 LEGAL LOCATION: NW 15-34-28-8 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Dune sand			0.21	8.6	fine sand	dry	L2	
			1.84	8.6	sand loam	dry	L4	-Battleford-like till from 1 to 7.5 feet
			2.88	8.6				
Oxidized till	1		3.34	8.5	clay loam	~10%	L2	
		5	3.40	8.4				
			3.24	8.3				
	2		3.31	8.3	clay	~15%		
							L3	-bottom 0.5 foot is Floral-like
	3	10						End of hole at 8 feet.

EM-38: 42/18

SITE: G. Gross TESTHOLE: OK 64 DATE: July 14/87 LEGAL LOCATION: SW 12-5-29-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess					loam	dry	L2	
Oxidized sandt					f.s. loam	dry	L4	
					fine sand	~15%	L2	
Oxidized lacustrine		5				saturated	L2	
	2				clay loam	saturated	L2	
								-free water in hole at 8 feet
Oxidized till	3	10			clay	saturated	L2	-Battleford-like till at 10 feet
	4							-Floral-like till at 12 feet
Unoxidized till	5	15			clay	near sat.	L2	
	6	20						
	7							-till remains very dense to 28 feet
	8	25						
								End of hole at 28 feet.
	9	30						

EM-38: 40/28

Y.S.I: 1.19 dS/m @ 25C

SITE: G. Gross TESTHOLE: OK 65 DATE: July 15/87 LEGAL LOCATION: SE 13-5-29-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			13.84	8.6	loam	saturated	L1	-very high amount of organic matter in the surface soil
Oxidized alluvium	1		5.76	8.2	clay	saturated	L1	-gypsum at 3 feet
		5	5.03	8.1				
			3.71	7.9				
	2		1.89	8.0				
Transitionally oxidized till			0.56	8.2	clay	saturated	L2	-iron stains between 7 and 9 feet
	3	10						
	4							-till becomes increasingly dense to 20 feet
		15						
	5		0.47	8.2				
		20						
Oxidized sand	6				fine sand	saturated		-sand is very easy to penetrate and water from the sand flowed to ground surface
	7							
		25						
	8							
								End of hole at 28 feet.
	9	30						

N.B. Water flowing from pipe at ~ 1 gallon per minute

EM-38: 190/240

Y.S.I: 2.40 dS/m @ 25C

SITE: A. Kuffner TESTHOLE: OK 66 DATE: July 15/87 LEGAL LOCATION: NE 7-5-29-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			5.56	8.3	clay loam	near sat.	L1	
Oxidized lacustrine	1		3.41	8.6	clay	saturated	L4	
			4.55	8.5				
		5	4.68	8.1				
			2.83	8.1				
Transitionally oxidized till	2				clay	saturated	L2	-Battleford-like till from 6 to 10 feet
			2.50	8.1				
	3	10						-Floral-like till from 10 to about 25 feet
	4							
	5	15						
	6	20	2.61	7.9				
	7							-free water in hole at 23 feet
	8	25			fine-med. sand	saturated	L2	-very well sorted and clean sand
Oxidized sand								
	9	30	1.62	8.1				
	10							
	11	35						
					clay	saturated	L2	
Oxidized lacustrine clay	12	40	2.21	7.8				
	13							
Oxidized sand					fine-med. sand	saturated	L2	-interlayers of lacustrine clay in the sand between ~38 and 43 feet
	14	45						
	15							
	16	50	2.11	7.7				
	17	55						
	18							
	19	60						
Oxidized lacustrine clay	20	65			clay	saturated	L2	-interlayers of sand in the lacustrine between ~ 63 and 68 feet
	21							
Oxidized sand		70	1.80	7.8	fine-med. sand	saturated	L2	-sand is more consolidated than that found above 63 feet
	22							
								End of hole at 73 feet
	23	75						

EM-38: 220/230

Y.S.I: 4.14 dS/m @ 25C

SITE: G. Gross TESTHOLE: OK 67 DATE: July 21/87 LEGAL LOCATION: NW 12-5-29-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess			6.08	8.1	clay loam	near sat.	L2	-visible salt precipitates in the surface soil
			5.59	8.2				
Alluvium?	1		4.71	8.1	sandy loam		L2	-gypsum at 2 feet
			3.74	8.1	clay		L3	
		5	4.15	8.0				
					clay	saturated	L2	-Battleford-like till at 6 feet
Oxidized till	2		5.59	7.9				
	3	10						-Floral-like till at 9 feet
			5.96	7.9			L2	
	4							
	5	15						
Oxidized sand			3.97	8.1	fine-med. sand	near sat.	L2	-sand is very dirty with pieces of clay in the sand
	6	20						
			4.80	7.9				
	7							
Oxidized till					clay	saturated	L2	
	8	25			clay	~20%	L3	-till becomes very difficult to drill with increasing depth
Unoxidized till			2.32	8.1				
	9	30						
	10							
		35						
	11		1.82	8.2				
	12	40						
	13							
		45						
	14							
	15	50						
	16							
		55						
Oxidized silt	17				silt	saturated	L1	-silt is a greenish color with changes to a bluish color by ~ 60 feet
	18	60						
	19							
	20	65	0.53	8.6				
	21							
		70						
	22							End of hole at 73 feet.
	23	75						

EM-38: 120/140

Y.S.I: 2.68 dS/m @ 25C

SITE: R. Pederson TESTHOLE: OK 68 DATE: July 26/87 LEGAL LOCATION: NE 6-18-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25 C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand					fine sand	dry	L2	
	1					saturated	L2	
Oxidized alluvium		5			silt loam	saturated	L3	
	2							
Oxidized lacustrine					clay	saturated	L2	
	3	10						
Oxidized till	4				sandy clay	near sat.	L2	-Battleford-like till (few stones)
	5	15						
	6	20						
	7				clay loam	near sat.	L2	-sandy interlayers in the Battleford till between 24 and 26 feet
	8	25						
	9	30			clay	~15%	L1	
Unoxidized till								-Floral-like till at 31 feet
	10							-spun auger from 33 to 68'
	11	35						
	12	40						
	13							
	14	45						
	15	50						
	16							
	17	55						
	18	60						
	19							
	20	65						
	21							End of hole at 68 feet.
		70						

SITE: R. Pederson TESTHOLE: OK 69 DATE: July 29/87 LEGAL LOCATION: NW 7-18-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand					fine sand	near sat.	L2	
						saturated		-material between 2 and 6
	1				loamy sand	saturated	L2	feet is super saturated and is very mucky and sticky
		5						
Oxidized lacustrine	2				clay loam	saturated	L4	
								-free water at 8 feet
	3	10						-sandy interbeds of fine oxidized sand between 10 and 12 feet
Oxidized till	4				sandy clay	near sat.	L3	
	5	15						
								End of hole at 18 feet.
	6	20						

EM-38: 120/125

Y.S.I: 3.10 dS/m @ 25C

SITE: R. Pederson TESTHOLE: OK 70 DATE: July 29/87 LEGAL LOCATION: NE 7-18-28-7 W3

Geologic Material	meters		feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand						fine sand	near sat.	L3	
	1					fine-med. sand	saturated	L2	-dirty sand layer from 3 to 9 feet
			5			loamy sand	saturated	L2	-free water at 3 feet
	2								
Oxidized till	3		10			sandy clay loam	saturated	L3	
	4								End of hole at 13 feet.
			15						

EM-38: 100/120

Y.S.I: 2.75 dS/m @ 25 C

SITE: R. Pederson TESTHOLE: OK 71 DATE: July 29/87 LEGAL LOCATION: NE 6-18-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand					loamy sand	near sat.	L3	
	1				loamy fine sand	saturated	L4	-sand is very dirty between 2 and 9 feet
		5			sandy loam	saturated	L2	
	2							
Oxidized gravel	3	10			course gravel	saturated	L2	
Oxidized till					clay loam	saturated	L1	-Battleford-like till at 10 feet
	4							End of hole at 13 feet.
		15						

EM-38: 110/110

Y.S.I: 6.37 dS/m @ 25C

SITE: B. Niska TESTHOLE: OK 72 DATE: July 30/87 LEGAL LOCATION: NW 15-22-27-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand					sandy loam	saturated	L1	
Alluvium	1				silty loam	saturated	L4	
		5			clay loam	saturated	L3	
Oxidized lacustrine	2							
	3	10			silty clay loam	saturated	L2	-rhizocretions in the lacustrine at 14 feet
	4							
		15						
	5							
Unoxidized lacustrine					clay	saturated	L4	-free water at 18 feet (5,491 uS/cm @ 25 C)
Unoxidized till	6	20			clay	saturated	L3	-Floral-like till at 20 feet
	7							
	8	25						
Oxidixed sand								
	9	30			fine to med. sand	saturated	L1	-sand is somewhat dirty in the first ~ 20 feet and appears cleaner from ~48 to 58 feet
	10							
		35						
	11							
	12	40						
	13							
		45						
	14							
	15	50						
	16							
		55						
	17							
	18							End of hole at 58 feet.
		60						

EM-38: 250/300

Y.S.I.: 3.30 dS/m @25C

SITE: G. Martyn TESTHOLE: OK 73 DATE: July 30/87 LEGAL LOCATION: SE 1-21-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Alluvium					clay loam	~10%	L4	
	1					saturated	L1	-gypsum at 4 and 9 feet
		5			clay	saturated	L3	
Oxidized till	2							
		10			clay	saturated	L2	-few iron stains in the unoxidized till
Unoxidized till	3							-pieces of bedrock shale in the unoxidized till
	4							
		15						
	5							
Unoxidized shale		20			clay	near sat.	L0	-shale surface appears very disturbed and crumbly
	6							
	7							
		25						
	8							End of hole at 28 feet.
	9	30						

EM-38: 190/200

SITE: S. Tomasiewicz TESTHOLE: OK 74 DATE: July 31/87 LEGAL LOCATION: NW 2-28-28-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess	1				loam	near sat.	L3	
Oxidized till	2	5			silt loam clay loam	saturated saturated	L4 L2	-large percentage of shale in the till between 7 and 25 feet
	3	10						-Battleford-like till from 4 to 25 feet
	4							
	5	15						
	6	20						
	7							
Oxidized bedrock sand	8	25			fine sand	saturated	L0	-shale modified till from 18 to 25 feet
Unoxidized bedrock sand	9	30			fine sand	saturated	L0	-sand is highly considated between 29 and 43 feet
	10							-lime pockets in the sand at 33 feet
	11	35						
Shale interbeds	12	40						-shale layers in the sand from 38 to 43 feet
	13							End of hole at 43 feet.
		45						

Y.S.I: 6.91 dS/m @ 25 C

SITE: A. Gifford TESTHOLE: OK 75 DATE: July 31/87 LEGAL LOCATION: NE 15-26-29-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized sand					loamy sand	dry	L0	
	1				fine sand	dry	L0	
		5			loamy sand	saturated	L2	
Oxidized lacustrine	2				clay	saturated	L2	
Oxidized till	3	10			clay	saturated	L2	-gypsum at 8 to 9 feet
	4							
	5	15						-Floral-like till at 17 feet -shale pieces in the till from 17 to 28 feet
	6	20						
	7							
	8	25						
Unoxidized sand								
Unoxidized shale	9	30			med. sand	saturated	L1	-sand appears to be Empress-like
					clay	saturated	LO	-sand is very dirty
	10							End of hole at 33 feet.
		35						

EM-38: 40/20

SITE: B. Derdall TESTHOLE: OK 76 DATE: July 31/87 LEGAL LOCATION: NW 7-32-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Oxidized lacustrine	1				clay	saturated	L2	-gypsum at 2 feet
		5						
	2							
Unoxidized till	3	10			clay	saturated	L2	-pieces of shale in the Floral-like till
	4							
	5	15						-free water at 18 feet
	6	20						-heavy iron staining at 21 feet
Unoxidized sand	7				v.f. sand	saturated	L1	-sand is very consolidated
	8	25						
Unoxidized silt	9	30			silt	saturated	L3	-silt is also very consolidated and is very brittle
	10						L1	
		35						
	11							
	12	40						
	13							
		45						
	14							
	15	50						
Unoxidized sand					v.f. sand	saturated	L1	
	16							
Unoxidized till					clay	saturated	L2	
	17	55						
	18							End of hole at 58 feet.
		60						

EM-38: 450/400

Y.S.I: 1.06 dS/m @ 25C

SITE: J. Kasper TESTHOLE: OK 77 DATE: Aug. 26/87 LEGAL LOCATION: NE 9-16-30-7 W3

Geologic Material	meters	feet	Cond. dS/m @ 25C	pH	Texture	Est. Moist.	Carb.	Comments
Loess	1				silt loam	near sat. saturated	L2 L3	-gypsum at 2 feet
Oxidized sand	2	5			silty sand	saturated	L2	-loaded with gypsum at 5 feet -sand is very silty and dirty
Unoxidized lacustrine	3	10			silty clay	saturated	L2	
Unoxidized till	4	15			clay loam	saturated	L2	-sand interbeds in the till at 18 feet
	5							
	6	20						
	7							
	8	25						
	9	30						-very shaley till from 30 to 35 feet
	10							
Unoxidized shale	11	35			clay	dry	L0	-shale appears dry and crumbly
	12	40						End of hole at 38 feet.

EM-38: 300/325

APPENDIX F

Analyes of soil samples from auger testholes

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						---------mg/L--------				--------meq/L--------			--meq/L--		
OK1	0-1	7.9	6.58	12.18	1625	644	49	245	70.7	40.3	1.3	6.9	112	122	16
	1-2	8.2	7.82	14.26	1845	826	22	320	80.2	51.6	0.6	9.0	132	143	16
	2-3	8.2	7.35	12.01	1686	563	41	259	73.3	35.2	1.1	7.3	110	120	17
	3-4	7.9	5.21	8.93	969	582	36	130	42.1	36.4	0.9	3.7	79	89	10
	4-6	8.0	4.90	8.99	965	592	37	127	42.0	37.0	0.9	3.6	80	90	10
	6-8	7.9	5.01	9.07	978	596	37	139	42.5	37.3	0.9	3.9	81	91	10
	8-10	7.9	4.58	8.41	883	558	34	141	38.4	34.9	0.9	4.0	74	84	9
	10-12	7.8	4.81	8.42	910	536	34	156	39.6	33.5	0.9	4.4	74	84	10
	12-14	7.8	4.43	7.96	826	532	31	135	35.9	33.3	0.8	3.8	70	80	9
	14-16	7.9	4.42	7.81	822	551	38	127	35.7	34.4	1.0	3.6	71	78	9
	16-20	8.4	3.08	5.51	688	248	33	113	29.9	15.5	0.8	3.2	46	55	11
	20-25	8.5	3.08	5.17	609	270	42	98	26.5	16.9	1.1	2.8	44	52	9
	25-28	8.5	2.81	4.91	592	238	46	104	25.7	14.9	1.2	2.9	42	49	9
	28-33		no sample												
	33-35	8.4	3.30	5.68	706	276	40	128	30.7	17.3	1.0	3.6	49	57	10
	35-40	8.6	2.16	sample would not filter											
	40-45	8.5	2.05	3.23	437	113	28	206	19.0	7.1	0.7	5.8	27	32	10
	45-50	8.5	1.68	2.85	405	83	29	100	17.6	5.2	0.7	2.8	24	29	11
	50-55	8.8	1.48	sample would not filter											
	55-60	8.3	3.04	4.93	526	405	50	83	22.9	25.3	1.3	2.3	49	49	6
	60-65	9.2	1.09	sample would not filter											
	65-70	8.9	1.42	1.86	270	48	21	58	11.7	3.0	0.5	1.6	15	19	10
	70-73	8.7	1.84	2.63	362	95	29	159	15.7	5.9	0.7	4.5	22	26	9
OK2	0-1	8.0	3.43	5.82	508	542	65	25	22.1	33.9	1.7	0.7	58	58	5
	1-2	8.1	3.17	5.39	453	522	38	18	19.7	32.6	1.0	0.5	53	54	5
	2-3	8.1	2.45	4.33	443	293	43	23	19.3	18.3	1.1	0.6	39	43	6
	3-4	8.0	1.51	2.25	161	176	59	17	7.0	11.0	1.5	0.5	20	23	3
	4-7	8.2	0.73	0.92	89	54	5	16	3.9	3.4	0.1	0.5	7	9	3
	7-9	8.0	1.20	1.54	118	115	7	16	5.1	7.2	0.2	0.5	12	15	3
	9-12	7.8	1.89	2.62	206	212	40	21	9.0	13.3	1.0	0.6	23	26	3
	12-15	7.7	2.62	4.28	196	547	45	17	8.5	34.2	1.2	0.5	44	43	2
	15-20	7.9	2.59	4.21	200	526	48	19	8.7	32.9	1.2	0.5	43	42	2
	20-25	8.0	2.42	4.10	232	485	47	19	10.1	30.3	1.2	0.5	42	41	3
	25-30	8.4	1.12	1.76	195	96	15	24	8.5	6.0	0.4	0.7	15	18	5
	30-34	8.4	1.09	1.74	212	80	14	25	9.2	5.0	0.4	0.7	15	17	6
	34-38	8.3	1.27	2.11	236	120	52	27	10.3	7.5	1.3	0.8	19	21	5
OK3	0-1	7.6	0.31	sample would not filter											
	1-2	8.2	0.22	sample would not filter											
	2-3	8.6	0.12	sample would not filter											
	3-4	8.5	0.28	sample would not filter											
	4-6	8.6	0.25	sample would not filter											
	6-8	8.8	0.20	sample would not filter											
	8-9	8.1	0.58	0.46	25	39	59	32	1.1	2.4	1.5	0.9	5	5	1
	9-12	7.9	0.58	sample would not filter											
	12-15	8.0	0.42	0.44	20	42	26	11	0.9	2.6	0.7	0.3	4	4	1
	15-19	8.0	0.40	0.44	20	43	32	13	0.9	2.7	0.8	0.4	4	4	1
	19-23	7.6	1.84	2.78	44	455	22	15	1.9	28.4	0.6	0.4	31	28	1
	23-28	7.7	1.46	2.31	49	327	17	16	2.1	20.4	0.4	0.5	23	23	1
OK4	0-1	8.0	1.34	2.00	262	85	44	21	11.4	5.3	1.1	0.6	18	20	7
	1-2	7.8	1.59	2.40	358	146	19	38	15.6	9.1	0.5	1.1	25	24	7
	2-3	7.9	1.20	1.82	255	85	34	22	11.1	5.3	0.9	0.6	17	19	7
	3-4	8.0	0.93	1.55	209	63	18	22	9.1	3.9	0.5	0.6	13	16	6
	4-8	8.1	0.34	0.48	37	36	10	10	1.6	2.3	0.3	0.3	4	5	2
	8-13	8.5	0.49	0.52	37	41	26	15	1.6	2.6	0.7	0.4	5	5	1
	13-15	8.5	0.37	0.45	30	36	18	14	1.3	2.3	0.5	0.4	4	5	1
	33-55	8.1	0.32	0.64	54	46	13	8	2.3	2.9	0.3	0.2	6	6	2
	55-68	8.7	0.39	0.37	34	22	18	10	1.5	1.4	0.5	0.3	3	4	2

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						---------mg/L--------				---------meq/L--------			--meq/L--		
OK 8	0-1	9.7	1.20	1.40	322	21	21	23	14.0	1.3	0.5	0.6	16	14	17
	1-2	9.4	0.60	0.70	134	16	23	7	5.8	1.0	0.6	0.2	7	7	8
	2-3	9.1	0.60	0.60	130	16	18	4	5.7	1.0	0.5	0.1	7	6	8
	3-4	9.3	0.50	0.50	104	10	16	4	4.5	0.6	0.4	0.1	6	5	8
	20-30	8.3	0.50	0.40	26	44	15	5	1.1	2.8	0.4	0.1	4	4	1
	30-42	8.4	0.60	0.50	66	33	13	4	2.9	2.1	0.3	0.1	5	5	3
	53-63	8.4	1.00	1.00	151	45	15	5	6.6	2.8	0.4	0.1	10	10	6
OK 9	0-1	8.3	0.85	1.39	249	31	17	27	10.8	1.9	0.4	0.8	13	14	11
	1-2	8.3	0.92	1.52	260	44	10	31	11.3	2.8	0.3	0.9	14	15	10
	2-3	8.2	0.73	1.05	103	83	7	22	4.5	5.2	0.2	0.6	10	11	3
	3-4	8.2	0.66	1.08	109	80	14	29	4.7	5.0	0.4	0.8	10	11	3
	4-7	8.2	0.75	0.96	100	73	31	35	4.3	4.6	0.8	1.0	10	10	3
	7-10	8.2	0.86	1.37	167	80	14	37	7.3	5.0	0.4	1.0	13	14	5
	10-13	7.9	3.00	4.64	477	416	16	35	20.7	26.0	0.4	1.0	47	46	6
	13-18	7.8	3.60	4.49	402	457	15	28	17.5	28.6	0.4	0.8	46	45	5
	18-23	7.8	3.22	4.39	410	445	18	25	17.8	27.8	0.5	0.7	46	44	5
	23-26	7.8	2.75	4.40	421	415	18	27	18.3	25.9	0.5	0.8	45	44	5
	26-31	7.7	2.83	4.73	514	413	18	39	22.3	25.8	0.5	1.1	49	47	6
	31-33	8.9	1.98	2.36	354	66	20	40	15.4	4.1	0.5	1.1	20	24	11
OK 10	0-1	8.1	0.72	1.07	88	90	14	41	3.8	5.6	0.4	1.2	10	11	2
	1-2	8.5	0.65	0.93	73	73	22	38	3.2	4.6	0.6	1.1	8	9	2
	2-3	8.7	0.61	0.85	80	56	19	61	3.5	3.5	0.5	1.7	7	9	3
	3-4	8.8	0.73	0.99	85	73	15	66	3.7	4.6	0.4	1.9	9	10	2
	4-8	8.7	0.57	0.71	57	53	14	17	2.5	3.3	0.4	0.5	6	7	2
	8-14	8.3	0.30	0.55	43	44	9	11	1.9	2.8	0.2	0.3	5	6	2
	14-15	8.3	0.34	0.74	65	53	10	17	2.8	3.3	0.3	0.5	6	7	2
	15-18	8.1	0.76	0.82	108	37	22	20	4.7	2.3	0.6	0.6	8	8	4
OK 11	0-1	8.7	0.56	0.78	72	49	10	29	3.1	3.1	0.3	0.8	6	6	3
	1-2	8.8	0.60	0.84	104	37	17	40	4.5	2.3	0.4	1.1	7	8	4
	2-3	9.0	1.14	1.69	211	67	30	62	9.2	4.2	0.8	1.7	14	17	6
	3-17	8.8	0.25	0.51	45	29	9	21	2.0	1.8	0.2	0.6	4	5	2
	17-23	8.1	0.50	0.48	42	35	20	15	1.8	2.2	0.5	0.4	5	5	2
	23-28	8.0	0.57	0.49	49	34	24	14	2.1	2.1	0.6	0.4	5	5	2
	28-31	8.2	0.43	0.56	47	41	11	14	2.0	2.6	0.3	0.4	5	6	2
	31-33	8.6	0.52	0.43	49	22	20	11	2.1	1.4	0.5	0.3	4	4	3
OK 14	0-1	7.5	1.03	1.62	136	152	8	20	5.9	9.5	0.2	0.6	16	16	3
	1-2	7.7	1.00	1.52	122	141	5	14	5.3	8.8	0.1	0.4	14	15	3
	2-3	7.7	1.07	1.82	141	177	9	20	6.1	11.1	0.2	0.6	17	18	3
	3-4	7.7	1.16	2.02	148	229	12	18	6.4	14.3	0.3	0.5	21	20	2
	4-5	7.9	1.38	2.41	185	279	15	23	8.0	17.4	0.4	0.6	26	24	3
	5-7	8.0	1.29	2.14	118	299	6	12	5.1	18.7	0.2	0.3	24	21	2
	7-12	8.0	2.74	3.60	225	470	10	10	9.8	29.4	0.3	0.3	39	36	3
	12-16	8.1	2.00	2.49	240	241	11	11	10.4	15.1	0.3	0.3	26	25	4
	16-20	7.9	2.39	4.01	366	466	16	20	15.9	29.1	0.4	0.6	45	40	4
	20-21	7.9	2.80	3.96	328	477	19	21	14.2	29.8	0.5	0.6	44	40	4
	21-28	7.7	3.80	3.64	269	453	21	12	11.7	28.3	0.5	0.3	41	36	3

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						--------mg/L--------				--------meq/L--------			--meq/L--		
OK16	0-1	8.0	3.99	6.72	840	588	19	55	36.5	36.8	0.5	1.5	74	67	9
	1-2	8.2	1.39	2.27	325	124	6	20	14.1	7.8	0.2	0.6	22	23	7
	2-3	8.1	2.52	4.47	526	350	15	39	22.9	21.9	0.4	1.1	45	45	7
	3-4	8.2	0.66	0.97	81	79	8	12	3.5	4.9	0.2	0.3	9	10	2
	4-8	8.2	0.78	1.15	95	108	11	17	4.1	6.8	0.3	0.5	11	12	2
	8-11	8.0	2.58	4.23	419	434	31	134	18.2	27.1	0.8	3.8	46	42	5
	11-14	8.2	0.59	0.63	52	52	22	11	2.3	3.3	0.6	0.3	6	6	2
	14-17	8.1	0.57	0.54	46	47	16	9	2.0	2.9	0.4	0.3	5	5	2
	17-23	7.9	1.90	2.81	117	415	16	14	5.1	25.9	0.4	0.4	31	28	1
	23-28	7.8	2.61	3.58	218	477	24	24	9.5	29.8	0.6	0.7	40	36	2
	28-33	7.9	2.49	3.40	187	493	23	13	8.1	30.8	0.6	0.4	40	34	2
	33-36	8.2	1.32	1.84	142	151	22	8	6.2	9.4	0.6	0.2	16	16	3
	36-39	8.3	1.77	2.35	262	214	25	20	11.4	13.4	0.6	0.6	25	24	4
	39-45	8.6	0.99	1.14	140	79	20	13	6.1	4.9	0.5	0.4	12	11	4
	45-50	8.6	0.79	0.94	127	53	21	14	5.5	3.3	0.5	0.4	9	9	4
	50-55	8.5	0.90	1.09	150	64	22	11	6.5	4.0	0.6	0.3	11	11	5
	55-60	8.2	1.55	2.21	264	201	22	24	11.5	12.6	0.6	0.7	25	22	5
	60-63	8.6	0.98	1.16	160	63	17	18	7.0	3.9	0.4	0.5	11	12	5
	63-68	8.5	0.72	0.79	118	34	13	12	5.1	2.1	0.3	0.3	8	8	5
	68-73	8.6	0.70	0.80	118	34	21	13	5.1	2.1	0.5	0.4	8	8	5
OK 17	0-1	7.9	3.19	5.74	252	7.07	19	112	11.0	0.4	0.5	3.2	12	57	23
	1-2	8.4	1.57	2.89	153	304	7	43	6.7	19.0	0.2	1.2	26	29	2
	2-3	8.7	1.06	1.81	158	125	18	35	6.9	7.8	0.5	1.0	15	18	3
	3-4	8.2	2.47	4.08	144	556	7	33	6.3	34.8	0.2	0.9	41	41	2
	4-5	8.2	2.26	3.73	83	540	7	43	3.6	33.8	0.2	1.2	38	37	1
	5-10	8.1	2.16	3.48	93	497	8	27	4.0	31.1	0.2	0.8	35	35	1
	10-15	8.1	1.07	1.61	61	190	23	21	2.7	11.9	0.6	0.6	15	16	1
	15-28	8.5	0.64	0.81	45	72	16	18	2.0	4.5	0.4	0.5	7	8	1
	28-33	8.4	0.56	0.69	49	52	19	14	2.1	3.3	0.5	0.4	6	7	2
	33-39	8.3	0.60	0.76	50	58	16	16	2.2	3.6	0.4	0.5	6	8	2
	39-42	8.3	0.71	1.13	90	87	14	15	3.9	5.4	0.4	0.4	10	11	2
	42-53	8.4	0.65	0.84	56	68	16	23	2.4	4.3	0.4	0.6	7	8	2
	53-64	8.4	0.61	0.81	63	59	16	19	2.7	3.7	0.4	0.5	7	8	2
	64-73	9.3	1.26 sample would not filter												
OK 18	0-1	8.6	1.69 sample would not filter												
	1-2	8.4	7.11 sample would not filter												
	2-3	8.3	9.84	14.98	3200	421	17	54	139.1	26.3	0.4	1.5	166	150	38
	3-4	8.3	8.47	13.80	2973	353	16	44	129.3	22.1	0.4	1.2	152	138	39
	4-7	8.0	5.24	9.10	1733	376	12	29	75.3	23.5	0.3	0.8	99	91	22
	7-8	8.0	5.49	9.40	1793	364	13	43	78.0	22.8	0.3	1.2	101	94	23
	8-10	7.8	6.09	8.58	1598	340	12	23	69.5	21.3	0.3	0.6	91	86	21
	10-13	9.6	3.20	4.09	780	24	8	24	33.9	1.5	0.2	0.7	36	41	39
OK 19	0-1	8.1	4.22	7.60	566	743	10	16	24.6	46.4	0.3	0.5	71	76	5
	1-2	8.3	2.48	4.25	328	356	10	92	14.3	22.3	0.3	2.6	37	43	4
	2-3	8.5	2.10	3.67	287	282	15	76	12.5	17.6	0.4	2.1	30	37	4
	3-4	8.0	3.34	5.84	279	692	21	82	12.1	43.3	0.5	2.3	56	58	3
	4-6	8.1	2.96	5.34	241	625	21	73	10.5	39.1	0.5	2.1	50	53	2
	6-8	8.1	2.32	3.96	114	544	14	31	5.0	34.0	0.4	0.9	39	40	1
	8-11	8.0	2.33	4.07	133	541	16	24	5.8	33.8	0.4	0.7	40	41	1
	11-13	8.0	1.78	3.03	113	373	13	25	4.9	23.3	0.3	0.7	29	30	1
	13-18	7.8	1.92	3.33	147	417	13	26	6.4	26.1	0.3	0.7	33	33	2
	18-23	8.1	0.95	1.38	111	102	12	19	4.8	6.4	0.3	0.5	12	14	3

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Total Salt*	SAR
						---------mg/L---------				---------meq/L---------			--meq/L--		
OK 22	0-1	7.6	2.22	3.83	177	438	29	40	7.7	27.4	0.7	1.1	36	38	2
	1-2	7.8	2.32	3.74	117	459	7	15	5.1	28.7	0.2	0.4	34	37	1
	2-3	8.3	1.28	2.01	213	109	7	20	9.3	6.8	0.2	0.6	16	20	5
	3-4	8.2	1.71	2.55	294	126	9	20	12.8	7.9	0.2	0.6	21	26	6
	4-10	7.9	2.87	4.31	259	426	15	23	11.3	26.6	0.4	0.6	38	43	3
	10-15	7.9	3.42	4.99	326	483	16	33	14.2	30.2	0.4	0.9	45	50	4
	15-30	7.9	3.11	5.10	352	471	19	51	15.3	29.4	0.5	1.4	45	51	4
	30-33	7.9	2.17	3.52	242	320	18	43	10.5	20.0	0.5	1.2	31	35	3
OK 28	0-1	7.6	1.61	2.68	126	352	38	28	5.5	22.0	1.0	0.8	28	27	2
	1-2	8.0	2.99	4.94	186	617	23	34	8.1	38.6	0.6	1.0	47	49	2
	2-3	8.1	2.56	4.34	124	570	16	20	5.4	35.6	0.4	0.6	41	43	1
	3-4	7.9	2.11	3.27	48	502	9	13	2.1	31.4	0.2	0.4	34	33	1
	4-8	8.0	0.67	0.65	30	67	15	15	1.3	4.2	0.4	0.4	6	7	1
	8-10	7.8	0.65	0.62	24	69	8	15	1.0	4.3	0.2	0.4	6	6	1
	10-12	7.7	0.91	0.91	18	124	11	12	0.8	7.8	0.3	0.3	9	9	0
	12-17	7.8	0.81	1.01	20	146	12	8	0.9	9.1	0.3	0.2	10	10	0
	17-22	7.6	1.76	2.68	34	418	14	12	1.5	26.1	0.4	0.3	28	27	0
	22-26	7.7	1.94	2.94	50	456	17	15	2.2	28.5	0.4	0.4	31	29	1
OK 29	0-1	7.6	3.98	6.62	683	568	21	153	29.7	35.4	0.5	4.3	66	66	7
	1-2	8.0	5.63	9.88	1131	795	3	273	49.2	49.7	0.1	7.7	99	99	10
	2-3	8.1	5.48	9.78	1083	781	3	272	47.1	48.8	0.1	7.7	96	98	10
	3-4	8.3	3.90	7.08	734	496	5	164	31.9	31.0	0.1	4.6	63	71	8
	4-5	8.0	3.54	5.74	493	495	8	93	21.4	30.9	0.2	2.6	53	57	5
	5-8	7.9	3.83	5.33	380	565	8	41	16.5	35.3	0.2	1.2	52	53	4
	8-13	7.8	2.60	4.21	242	493	10	44	10.5	30.8	0.3	1.2	42	42	3
	13-18	7.7	1.87	3.24	240	320	13	55	10.4	20.0	0.3	1.5	31	32	3
OK 31	0-1	8.2	2.38	3.99	177	362	108	31	7.7	22.6	2.8	0.9	33	40	2
	1-2	8.2	0.87	1.34	32	115	62	16	1.4	7.2	1.6	0.5	10	13	1
	2-3	8.3	0.97	1.72	40	174	41	8	1.7	10.9	1.1	0.2	14	17	1
	3-4	8.3	1.27	1.82	50	190	42	9	2.2	11.9	1.1	0.3	15	18	1
	4-6	8.3	0.82	1.06	29	114	25	9	1.3	7.1	0.6	0.3	9	11	1
	6-8	8.4	0.38	0.48	19	49	12	9	0.8	3.1	0.3	0.3	4	5	1
	8-12	8.0	0.54	0.45	12	52	14	16	0.5	3.3	0.4	0.5	4	5	0
	12-13	8.7	0.31	0.19	7	20	10	8	0.3	1.3	0.3	0.2	2	2	0
	13-18	8.6	0.31	0.32	15	32	8	12	0.7	2.0	0.2	0.3	3	3	1
OK 36	0-1	7.7	3.11	5.01	474	466	21	20	20.6	29.1	0.5	0.6	50	50	5
	1-2	7.7	1.81	2.84	169	346	5	10	7.3	21.6	0.1	0.3	29	28	2
	2-3	8.0	0.63	0.86	38	85	3	10	1.7	5.3	0.1	0.3	7	9	1
	3-6	7.8	1.19	2.01	61	237	7	7	2.7	14.8	0.2	0.2	18	20	1
	6-12	8.1	0.53	0.43	25	38	5	15	1.1	2.3	0.1	0.4	3	4	1
	12-18	8.0	0.37	0.43	30	36	5	8	1.3	2.3	0.1	0.2	4	4	1
OK 37	0-1	7.5	2.78	4.64	293	510	23	386	12.7	31.9	0.6	10.9	45	46	3
	1-2	8.2	2.62	4.31	341	348	7	136	14.8	21.8	0.2	3.8	37	43	4
	2-3	8.2	2.80	4.51	361	347	8	147	15.7	21.7	0.2	4.1	38	45	5
	3-5	8.2	2.00	3.17	218	294	14	77	9.5	18.4	0.4	2.2	28	32	3
	5-9	7.8	3.54	4.54	192	549	17	49	8.3	34.3	0.4	1.4	43	45	2
	9-13	7.8	2.40	3.67	137	496	17	47	6.0	31.0	0.4	1.3	37	37	2

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension extract		Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						---------mg/L--------				--------meq/L-------			--meq/L--		
OK 38	0-1	7.6	1.61	2.39	165	234	31	26	7.2	14.6	0.8	0.7	23	24	3
	1-2	7.6	1.48	2.17	80	292	12	8	3.5	18.3	0.3	0.2	22	22	1
	2-3	7.8	1.15	1.49	70	168	10	15	3.0	10.5	0.3	0.4	14	15	1
	3-4	7.8	1.09	1.14	45	125	11	17	2.0	7.8	0.3	0.5	10	11	1
	4-6	7.8	1.14	1.22	63	126	11	17	2.7	7.9	0.3	0.5	11	12	1
	6-8	7.9	1.48	2.34	180	173	11	17	7.8	10.8	0.3	0.5	19	23	3
OK 39	0-1	7.9	3.75	6.31	452	587	15	42	19.7	36.7	0.4	1.2	57	63	5
	1-2	8.1	4.57	7.42	555	572	12	89	24.1	35.8	0.3	2.5	60	74	6
	2-3	8.0	5.85	11.19	849	878	15	147	36.9	54.9	0.4	4.1	92	112	7
	3-5	7.8	6.25	8.97	523	818	15	57	22.7	51.1	0.4	1.6	74	90	4
	5-8	7.8	2.80	4.44	197	520	12	28	8.6	32.5	0.3	0.8	41	44	2
OK 44	0-1	8.0	4.60	8.38	1123	422	4	48	48.8	26.4	0.1	1.4	75	84	13
	1-2	8.2	3.52	5.84	853	194	18	39	37.1	12.1	0.5	1.1	50	58	15
	2-3	8.2	3.73	6.18	910	203	20	45	39.6	12.7	0.5	1.3	53	62	16
	3-4	8.1	5.19	8.58	1178	331	25	74	51.2	20.7	0.6	2.1	73	86	16
	4-6	8.0	6.79	10.86	1340	555	28	86	58.3	34.7	0.7	2.4	94	109	14
	6 7	7.9	6.65	9.69	1167	500	25	78	50.7	31.3	0.6	2.2	83	97	13
	7-8	7.9	6.08	10.34	1234	529	24	83	53.7	33.1	0.6	2.3	87	103	13
OK 45	0-1	8.3	3.35	6.27	661	354	274	73	28.7	22.1	7.0	2.1	58	63	9
	1-2	8.1	1.45	2.57	215	123	194	48	9.3	7.7	5.0	1.4	22	26	5
	2-3	7.6	0.50	0.68	32	51	40	9	1.4	3.2	1.0	0.3	[illegible]	7	1
	3-4	7.6	0.53	0.64	29	52	36	10	1.3	3.3	0.9	0.3	5	6	1
	4-5	7.6	0.77	0.99	50	81	44	15	2.2	5.1	1.1	0.4	8	10	1
	5-7	7.9	0.67	0.60	20	44	25	9	0.9	2.8	0.6	0.3	4	6	1
	7-8	8.0	0.48	0.57	21	42	18	11	0.9	2.6	0.5	0.3	4	6	1
OK 46	0-1	8.2	7.19	12.59	1539	1007	38	55	66.9	62.9	1.0	1.5	131	126	12
	1-2	8.5	5.28	8.99	901	795	26	28	39.2	49.7	0.7	0.8	90	90	8
	2-3	8.6	6.99	11.71	1294	896	28	28	56.3	56.0	0.7	0.8	113	117	11
	3-4	8.4	8.35	12.53	1408	1039	26	40	61.2	64.9	0.7	1.1	127	125	11
	4-11	8.1	9.02	13.60	1456	1148	24	34	63.3	71.8	0.6	1.0	136	136	11
	11-17	8.1	6.01	9.80	929	810	21	25	40.4	50.6	0.5	0.7	92	98	8
	17-20	8.1	7.22	11.59	1250	998	27	38	54.3	62.4	0.7	1.1	117	116	10
	20-24	8.5	5.50	9.16	1007	745	23	29	43.8	46.6	0.6	0.8	91	92	9
	24-28	8.3	3.82	6.27	667	510	22	33	29.0	31.9	0.6	0.9	61	63	7
OK 47	0-1	8.0	9.30	16.58	3903	353	20	44	169.7	22.1	0.5	1.2	192	166	51
	1-2	8.1	11.45	18.98	4254	567	9	90	185.0	35.4	0.2	2.5	221	190	44
	2-3	8.0	10.76	17.84	3792	567	12	100	164.9	35.4	0.3	2.8	201	178	39
	3-8	8.0	4.21	7.09	1399	179	12	33	60.8	11.2	0.3	0.9	72	71	26
	8-13	7.7	5.64	9.32	1760	377	16	32	76.5	23.6	0.4	0.9	100	93	22
	13-18	7.6	6.34	9.65	1901	332	18	44	82.7	20.8	0.5	1.2	104	97	26
	18-22	7.3	4.84	6.98	1340	22	15	42	58.3	1.4	0.4	1.2	60	70	70
	22-27	9.0	2.56	3.18	602	19	10	34	26.2	1.2	0.3	1.0	28	32	34
	27-28	9.5	2.55	2.60	485	12	8	37	21.1	0.8	0.2	1.0	22	26	34

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
						mg/L				meq/L			meq/L		
OK 55	0-1	7.8	3.05	5.28	609	435	38	73	26.5	27.2	1.0	2.1	55	53	7
	1-2	8.2	7.64	13.12	2295	709	8	34	99.8	44.3	0.2	1.0	144	131	21
	2-3	8.2	6.70	9.95	1501	540	10	20	65.3	33.8	0.3	0.6	99	100	16
	3-4	8.1	6.39	10.48	1553	663	12	25	67.5	41.4	0.3	0.7	109	105	15
	4-14	7.9	2.71	4.15	479	380	10	19	20.8	23.8	0.3	0.5	45	42	6
	14-17	7.9	1.41	2.18	325	122	9	19	14.1	7.6	0.2	0.5	22	22	7
	17-22	7.7	2.02	3.01	394	221	11	21	17.1	13.8	0.3	0.6	31	30	7
	22-27	7.6	0.47	0.44	75	6	3	11	3.3	0.4	0.1	0.3	4	4	8
	27-38	8.9	0.52	0.51	111	6	3	11	4.8	0.4	0.1	0.3	5	5	11
OK 56	0-1	7.8	8.93	15.44	3554	457	13	21	154.5	28.8	0.3	0.6	183	154	41
	1-2	8.3	2.55	4.05	866	77	3	13	37.7	4.8	0.1	0.4	43	41	24
	2-3	8.3	2.12	3.24	664	63	3	14	28.9	3.9	0.1	0.4	33	32	21
	3-4	8.0	5.03	8.19	1706	331	9	20	74.2	20.7	0.2	0.6	95	82	23
	4-9	8.0	4.32	6.87	1233	349	10	15	53.6	21.8	0.3	0.4	76	69	16
	9-14	7.9	3.56	5.90	971	308	12	13	42.2	19.3	0.3	0.4	62	59	14
	14-19	7.9	3.28	5.38	931	257	12	14	40.5	16.1	0.3	0.4	57	54	14
	19-23	8.5	0.98	1.57	287	12	33	15	12.5	0.8	0.8	0.4	14	16	20
	23-29	8.5	1.08	1.74	316	16	20	30	13.7	1.0	0.5	0.8	15	17	19
	29-33	9.2	1.03	1.08	200	5	19	15	8.7	0.3	0.5	0.4	9	11	22
OK 58	0-1	8.4	11.69	19.90	3953	424	12	150	171.9	26.5	0.3	4.2	199	199	47
	1-2	8.1	4.98	8.19	1402	233	3	41	61.0	14.6	0.1	1.2	76	82	23
	2-3	8.3	3.77	6.07	1116	97	5	39	48.5	6.1	0.1	1.1	55	61	28
	3-4	8.0	5.46	7.95	1216	323	9	36	52.9	20.2	0.2	1.0	73	80	17
	4-9	7.9	3.80	5.78	749	323	12	43	32.6	20.2	0.3	1.2	53	58	10
	9-20	7.9	1.75	2.76	379	128	15	25	16.5	8.0	0.4	0.7	25	28	8
	20-25	8.0	1.67	2.85	389	135	15	27	16.9	8.4	0.4	0.8	26	29	8
	25-28	7.4	4.21	5.36	748	306	21	21	32.4	19.1	0.5	0.6	52	54	10
OK 59	0-1	7.9	7.82	12.89	1918	392	44	155	83.4	24.5	1.1	4.4	109	129	24
	1-2	8.1	3.41	5.82	560	306	7	34	24.3	19.1	0.2	1.0	44	58	6
	2-3	8.1	2.06	3.01	242	185	9	19	10.5	11.6	0.2	0.5	22	30	4
	3-4	7.9	3.37	4.71	341	382	15	23	14.8	23.9	0.4	0.6	39	47	4
	4-7	7.9	2.66	4.26	260	412	17	22	11.3	25.8	0.4	0.6	37	43	3
	7-13	6.8	3.16	4.18	308	345	27	26	13.4	21.6	0.7	0.7	36	42	4
OK 61	0-1	7.9	7.17	11.93	1561	678	71	116	67.9	42.4	1.8	3.3	112	119	15
	1-2	8.2	8.11	12.85	1790	885	30	142	77.8	42.8	0.8	4.0	121	129	17
	2-3	8.2	8.48	14.50	2160	707	31	138	93.9	44.2	0.8	3.9	139	145	20
	3-4	8.2	9.03	15.44	2371	761	32	152	103.1	47.6	0.8	4.3	151	154	21
	4-5	8.0	8.71	14.50	2214	707	30	140	96.3	44.2	0.8	3.9	141	145	20
	5-7	8.2	7.85	12.82	1790	674	28	125	77.8	42.1	0.7	3.5	121	126	17
	7-9	8.1	6.10	9.95	1251	563	25	87	54.4	35.2	0.6	2.5	90	100	13
	9-12	8.0	6.87	11.12	1403	602	27	103	61.0	37.6	0.7	2.9	99	111	14
	12-13	7.8	5.72	8.76	1015	517	24	78	44.1	32.3	0.6	2.2	77	88	11
	13-16	8.1	5.49	9.65	1064	596	25	102	46.3	37.3	0.6	2.9	84	97	11
	16-23	8.0	4.58	7.32	790	468	26	72	34.3	29.3	0.7	2.0	64	73	9
	23-28	7.9	3.86	6.07	641	418	27	69	27.9	26.1	0.7	1.9	55	61	8
	28-40	8.4	1.65	2.24	241	148	22	45	10.5	9.3	0.6	1.3	20	22	5
	40-45	7.9	2.65	4.79	486	358	20	87	21.1	22.4	0.7	2.5	44	48	6

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	Conductivity dS/m @ 25C extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Total Salt*	SAR
					--------mg/L--------				--------meq/L--------				--meq/L--		
OK 62	0-1	7.5	2.41	4.17	672	184	45	54	29.2	11.5	1.2	1.5	42	42	12
	1-2	8.4	6.54	11.67	2599	167	12	61	113.0	10.4	0.3	1.7	124	117	49
	2-3	8.5	5.96	10.29	2210	165	14	52	96.1	10.3	0.4	1.5	107	103	42
	3-4	8.0	7.28	10.69	2100	365	16	42	91.3	22.8	0.4	1.2	115	107	27
	4-8	7.9	4.90	7.84	1430	274	17	37	62.2	17.1	0.4	1.0	80	78	21
	8-12	7.8	4.83	7.59	1399	242	18	38	60.8	15.1	0.5	1.1	76	76	22
	12-17	8.2	2.99	4.60	868	100	14	38	37.7	6.3	0.4	1.1	44	46	21
	17-28	8.6	1.78	2.65	512	24	12	39	22.3	1.5	0.3	1.1	24	27	26
	28-30	8.5	1.71	2.88	582	35	14	51	25.3	2.2	0.4	1.4	28	29	24
	30-32	8.3	1.63	2.37	438	30	12	35	19.0	1.9	0.3	1.0	21	24	20
	32-42	8.3	3.53	4.83	720	232	26	27	31.3	14.5	0.7	0.8	46	48	12
	42-62	8.2	3.39	4.15	539	262	29	21	23.4	16.4	0.7	0.6	41	42	8
	62-73	8.3	2.56	3.37	453	184	24	23	19.7	11.5	0.6	0.6	32	34	8
OK 63	0-1	8.6	0.21	0.25	19	18	6	6	0.8	1.1	0.2	0.2	2	3	1
	1-2	8.6	1.84	2.59	227	292	7	63	9.9	18.3	0.2	1.8	28	26	3
	2-3	8.6	2.88	4.64	391	592	12	91	17.0	37.0	0.3	2.6	54	46	4
	3-4	8.5	3.34	5.33	447	694	19	85	19.4	43.4	0.5	2.4	63	53	4
	4-6	8.4	3.40	5.75	429	792	21	78	18.7	49.5	0.5	2.2	69	58	4
	6-7.5	8.3	3.24	5.31	376	762	23	66	16.3	47.6	0.6	1.9	65	53	3
	7.5-8	8.3	3.31	5.52	407	728	22	71	17.7	45.5	0.6	2.0	64	55	4
OK 65	0-1	8.6	13.84	22.98	5034	933	110	309	218.9	58.3	2.8	8.7	280	230	41
	1-2	8.2	5.76	8.69	1473	491	15	42	64.0	30.7	0.4	1.2	95	87	16
	2-3	8.1	5.03	6.72	917	536	6	17	39.9	33.5	0.2	0.5	74	67	10
	3-4	7.9	3.71	4.72	469	522	6	17	20.4	32.6	0.2	0.5	53	47	5
	4-7	8.0	1.89	2.19	171	240	7	12	7.4	15.0	0.2	0.3	23	22	3
	7-8	8.2	0.56	0.61	87	39	17	15	2.9	2.4	0.4	0.4	6	6	3
	8-18	8.2	0.47	0.67	62	36	23	18	2.7	2.3	0.6	0.5	6	7	3
OK 66	0-1	8.3	5.56	10.36	1314	1050	10	188	57.1	65.6	0.3	5.3	123	104	10
	1-2	8.6	3.41	6.04	688	579	6	125	29.9	36.2	0.2	3.5	66	60	7
	2-3	8.5	4.55	6.32	680	636	9	128	29.6	39.8	0.2	3.6	70	63	7
	3-4	8.1	4.68	6.15	519	749	11	62	22.6	46.8	0.3	1.7	70	62	5
	4-6	8.1	2.83	3.70	239	475	9	20	10.4	29.7	0.2	0.6	40	37	3
	6-15	8.1	2.50	3.86	241	505	11	38	10.5	31.6	0.3	1.1	42	39	3
	15-25	7.9	2.61	3.86	212	546	16	39	9.2	34.1	0.4	1.1	44	39	2
	25-38	8.1	1.62	2.65	98	436	15	20	4.3	27.3	0.4	0.6	32	27	1
	38-43	7.8	2.21	3.26	88	5.49	21	20	3.8	0.3	0.5	0.6	5	33	9
	43-63	7.7	2.11	3.09	75	505	19	19	3.3	31.6	0.5	0.5	35	31	1
	63-68			no sample											
	68-73	7.8	1.80	2.68	52	459	14	18	2.3	28.7	0.4	0.5	31	27	1
OK 67	0-1	8.1	6.08	8.98	1659	416	53	49	72.1	26.0	1.4	1.4	99	90	20
	1-2	8.2	5.59	7.89	1402	420	38	30	61.0	26.3	1.0	0.8	88	79	17
	2-3	8.1	4.71	6.94	1156	446	27	22	50.3	27.9	0.7	0.6	79	69	13
	3-4	8.1	3.74	5.73	826	453	19	22	35.9	28.3	0.5	0.6	65	57	10
	4-5	8.0	4.15	5.88	766	552	19	17	33.3	34.5	0.5	0.5	68	59	8
	5-8	7.9	5.59	8.43	1226	749	23	37	53.3	46.8	0.6	1.0	101	84	11
	8-13	7.9	5.96	9.57	1361	886	26	61	59.2	55.4	0.7	1.7	115	96	11
	13-18			no sample											
	18-21	8.1	3.97	7.49	744	726	23	67	32.3	45.4	0.6	1.9	78	75	7
	21-24	7.9	4.80	7.41	914	803	23	58	39.7	50.2	0.6	1.6	91	74	8
	24-33	8.1	2.32	3.48	302	441	22	42	13.1	27.6	0.6	1.2	41	35	4
	33-38	8.2	1.82	2.43	169	340	22	32	7.3	21.3	0.6	0.9	29	24	2
	38-55			no sample											
	55-73	8.6	0.53	0.62	67	37	22	11	2.9	2.3	0.6	0.3	6	6	3

Appendix F. Analyses of soil samples from auger testholes (1:1 (soil:water) analyses)

Testhole No.	DEPTH (feet)	pH	Conductivity dS/m @ 25C suspension	extract	Na	Ca+Mg	K	Cl	Na	Ca+Mg	K	Cl	Total Cation	Salt*	SAR
					---------mg/L--------					--------meq/L--------			--meq/L--		
OK 68	0-4	8.4	0.88	1.36	87	166	28	57	3.8	10.4	0.7	1.6	15	14	2
	4-8	8.5	0.33	0.38	15	42	16	10	0.7	2.6	0.4	0.3	4	4	1
	8-12	7.9	2.39	3.01	29	604	25	16	1.3	37.8	0.6	0.5	40	30	0
	12-22	7.9	2.00	2.94	57	545	25	16	2.5	34.1	0.6	0.5	37	29	1
	22-30	7.9	1.99	2.99	78	542	27	19	3.4	33.9	0.7	0.5	38	30	1
	30-33	7.8	2.22	3.08	106	523	27	19	4.6	32.7	0.7	0.5	38	31	1
OK 69	0-2	8.0	2.47	4.19	196	671	17	30	8.5	41.9	0.4	0.8	51	42	2
	2-6	7.9	2.98	4.94	296	737	21	54	12.9	46.1	0.5	1.5	59	49	3
	6-12	8.4	1.00	1.20	90	123	17	18	3.9	7.7	0.4	0.5	12	12	2
	12-18	8.2	0.82	1.05	78	111	23	21	3.4	6.9	0.6	0.6	11	11	2
OK 72	0-3	8.1	5.44	8.99	775	1208	34	73	33.7	75.5	0.9	2.1	110	90	5
	3-5	8.3	2.09	3.00	253	342	14	21	11.0	21.4	0.4	0.6	33	30	3
	5-10	8.2	2.26	2.94	221	376	12	18	9.6	23.5	0.3	0.5	33	29	3
	10-17	8.0	3.40	4.41	183	774	16	12	8.0	48.4	0.4	0.3	57	44	2
	17-23	7.9	3.14	4.52	228	723	23	21	9.9	45.2	0.6	0.6	56	45	2
	23-28	7.8	2.17	3.17	118	549	26	25	5.1	34.3	0.7	0.7	40	32	1
	28-58	7.7	1.82	3.13	90	553	30	29	3.9	34.6	0.8	0.8	39	31	1
OK 73	0-1	8.5	6.91	11.99	2135	623	36	143	92.8	38.9	0.9	4.0	133	120	21
	1-2	8.3	4.29	7.58	1121	532	33	58	48.7	33.3	0.8	1.6	83	76	12
	2-3	8.1	3.49	5.23	596	528	19	25	25.9	33.0	0.5	0.7	59	52	6
	3-5	7.9	3.20	4.51	402	560	5	21	17.5	35.0	0.1	0.6	53	45	4
	5-9	7.9	3.37	4.87	466	575	6	22	20.3	35.9	0.2	0.6	56	49	5
	9-19	8.7	3.29	4.81	756	238	15	55	32.9	14.9	0.4	1.5	48	48	12
	19-28	8.4	3.33	4.02	627	152	12	31	27.3	9.5	0.3	0.9	37	40	13
OK 76	0-5	8.3	10.18	15.93	1735	2033	22	86	75.4	127.1	0.6	1.9	203	159	9
	5-10	8.1	6.74	9.73	979	1218	22	52	42.6	76.1	0.6	1.5	119	97	7
	10-16	8.1	2.38	3.71	374	404	19	32	16.3	25.3	0.5	0.9	42	37	5
	16-23	8.2	0.95	1.27	111	126	24	15	4.8	7.9	0.6	0.4	13	13	2
	23-30	8.1	1.62	2.49	178	323	23	25	7.7	20.2	0.6	0.7	28	25	2
	30-50	8.2	0.83	1.30	83	158	23	13	3.6	9.9	0.6	0.4	14	13	2
	50-53	8.1	0.81	1.20	84	136	19	11	3.7	8.5	0.5	0.3	13	12	2
	53-58	8.3	0.73	0.87	76	75	18	14	3.3	4.7	0.5	0.4	8	9	2

*Salt = E.C. extract * 10

APPENDIX G

Specificiations of piezometers installed by auger and rotary drill

Appendix G. Specifications of piezometers installed by auger and rotary drill.

Farmer Legal Description	Site	Piezometer Name Approx. depth (ft.)	Date Installed	Total	Length of pipe Above ground	Below ground	Length of Screen (meters)
				--------(meters)--------			
Larson R.	OK1	3' piez	Apr/30/87	1.68	0.95	0.73	0.32
NW 15-36-29-8 W3		8' piez	Apr/30/87	3.59	0.96	2.63	0.39
		18' piez	Apr/30/87	6.51	0.93	5.58	0.37
		31' piez	Apr/30/87	10.63	0.97	9.66	0.38
		43' piez	Apr/30/87	14.48	1.12	13.36	0.38
Larson R.	OK2	5' piez	Apr/30/87	2.21	0.53	1.68	0.38
SE 15-36-29-8 W3		18' piez	Apr/30/87	6.54	0.71	5.83	0.39
		38' piez	Apr/30/87	12.58	0.73	11.85	0.38
Larson R.	OK5	10' piez	May/01/87	3.53	0.36	3.17	0.34
NW 15-36-29-8 W3							
Davison B.	OK9	5' piez	May/05/87	2.74	1.03	1.71	0.76
SW 05-03-30-8 W3							
M1-84-RH06		48' piez	May/11/87	15.94	0.93	15.01	0.39
NW 13-26-28-7 W3							
Larson R.&M.	OK29	5' piez	May/17/87	2.52	1.14	1.38	0.39
SW 02-30-30-7 W3		15' piez	May/17/87	5.38	0.89	4.49	0.40
		30' piez	May/17/87	9.63	0.94	8.69	0.39
		50' piez	May/17/87	16.08	1.02	15.06	0.39
		70' piez	May/17/87	22.05	0.73	21.32	0.37
Larson R.&M.	OK36	5' piez	May/25/87	2.54	1.01	1.53	0.39
SW 02-30-30-7 W3		18' piez	May/25/87	6.54	0.74	5.80	0.39
Larson R.&M.	OK 37	5' piez	May/25/87	1.98	0.76	1.22	0.39
SW 02-30-30-7 W3		13' piez	May/25/87	5.02	0.95	4.07	0.39
Larson R.&M.	OK 38	8' piez	May/25/87	2.92	0.42	2.50	0.37
SW 02-30-30-7 W3							
Larson R.&M.	OK 39	3' piez	May/25/87	2.12	1.05	1.07	0.40
SW 02-30-30-7 W3		8' piez	May/25/87	3.59	1.17	2.42	0.40

Appendix G. Specifications of piezometers installed by auger and rotary drill.

Farmer Legal Description	Site	Piezometer Name Approx. depth (ft.)	Date Installed	Total	Length of pipe Above ground	Below ground	Length of Screen (meters)
				--------(meters)--------			
Duncan A.	OK 47	8' piez	Oct/01/87	3.34	0.90	2.44	0.38
SW 04-03-30-7 W3		20' piez	Jun/18/87	7.28	1.06	6.22	0.30
		28' piez	Jun/04/87	9.73	0.97	8.76	0.37
		73' piez	Jun/18/87	19.39	1.07	18.32	0.31
Tomasiewicz S.	OK 56	8' piez	Jun/11/87	3.33	0.94	2.39	0.38
NE 06-28-28-7 W3		18' piez	Jun/11/87	6.54	0.82	5.72	0.39
		28' piez	Jun/11/87	8.61	0.87	7.74	0.40
Martyn G.	OK 58	18' piez	Jun/15/87	6.52	0.79	5.73	0.39
SE 04-33-28-7 W3							
Ivan L.	OK 59	8' piez	Jun/15/87	3.62	1.17	2.45	0.38
NW 12-07-28-6 W3		13' piez	Jun/15/87	4.88	0.92	3.96	0.40
Tomecek W.	OK 61	10' piez	Jun/16/87	3.95	0.83	3.12	0.34
SW 03-05-29-6 W3		43' piez	Jun/16/87	13.50	0.82	12.68	0.32
		73' piez	Jun/16/87	21.61	0.92	20.69	0.31
Peters E.	OK 62	28' piez	Jun/18/87	9.04	0.95	8.09	0.30
NW 14-24-30-6 W3							
Gross G.	OK 65A	28' piez	Jul/15/87	Piezometer pulled, faulty seal.			0.69
SE 13-05-29-7 W3	OK 65B	33' piez	Aug/24/87	11.24	0.84	10.40	Open
Kufner A.	OK 66	21' piez	Jul/21/87	7.82	1.12	6.70	0.76
NE 07-05-29-7 W3							
Pederson R.	OK 69	6' piez	Jul/29/87	2.46	0.84	1.62	0.32
NW 07-18-28-7 W3		18' piez	Jul/29/87	6.47	0.82	5.65	0.32
		28' piez	Jul/29/87	9.67	0.85	8.82	0.32
Niska B.	OK 72	31' piez	Jul/30/87	10.68	1.34	9.34	0.76
NW13-22-27-7 W3							
Martyn G.	OK 73	25' piez	Jul/30/87	8.67	1.19	7.48	0.34
SE 01-21-28-7 W3							
Gifford A.	OK 74	31' piez	Jul/31/87	10.68	1.15	9.53	0.76
NE 15-26-29-7 W3		9' well		4.12	1.30	2.82	-

Appendix G. Specifications of piezometers installed by auger and rotary drill.

Farmer Legal Description	Site	Piezometer Name Approx. depth (ft.)	Date Installed	Total	Length of pipe Above ground (meters)	Below ground	Length of Screen (meters)
Derdall B. NW 07-32-30-7 W3	OK 76	28' piez	Aug/24/87	10.08	1.22	8.86	0.76
Kasper J. NE 09-16-30-7 W3	OK 77	8' piez	Aug/26/87	2.90	1.08	1.82	0.33
		38' piez	Aug/26/87	12.48	1.11	11.37	0.31
Gifford A. NW 13-26-29-7 W3	OK 10E	23' piez	Jun/26/87	7.57	0.70	6.87	0.76
Stone G. NE 08-07-27-6 W3	OK 11E	271' piez	Aug/27/87	83.47	0.87	82.60	0.91

* These piezometers were installed by rotary hydraulic, the remainder were installed by 6" diameter solid stem auger.

All piezometer nests measured to the same internal datum.

APPENDIX H

Water level measurements from piezometers

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 3' piez	8' piez	18' piez	31' piez	43' piez
			Piezometer length below ground surface (m) 0.73	2.63	5.58	9.66	13.36
			Water level readings b.g.s. (m)				
Larson R.	OK 1	May 1, 1987	dry	2.27	dry	8.38	dry
		May 4, 1987	dry	1.64	5.24	8.11	13.24
		Jun 2, 1987	dry	1.62	1.67	3.73	8.94
		Jun 16, 1987	dry	1.68	1.90	3.01	7.09
		Jun 24, 1987	dry	1.77	1.76	2.74	6.29
		Jul 20, 1987	dry	1.94	1.89	2.24	5.43
		Aug 17, 1987	dry	1.72	1.65	1.85	3.22
		Sep 21, 1987	dry	1.93	1.85	1.79	2.25
		Nov 9, 1987	dry	2.07	2.05	1.85	1.70
		Jan 18, 1988	dry	2.09	2.06	1.95	1.76
		Mar 16, 1988	dry	2.43	2.48	2.36	2.19
		Mar 21, 1988	dry	2.34	2.39	2.31	2.17

Name	Site	Date	Piezometer name (approximate depth)* 5' piez	18' piez	38' piez
			Piezometer length below ground surface (m) 1.68	5.83	11.85
			Water level readings b.g.s. (m)		
Larson R.	OK 2	May 1, 1987	1.54	3.54	9.07
		May 4, 1987	1.52	1.77	5.87
		Jun 24, 1987	dry	1.81	1.83
		Jul 20, 1987	dry	1.88	1.95
		Sep 21, 1987	dry	2.00	1.87
		Nov 9, 1987	dry	2.04	1.90
		Jan 18, 1988	dry	2.19	1.97
		Mar 21, 1988	dry	2.07	2.05

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 10' piez Piezometer length below ground surface (m) 3.17 Water level readings b.g.s. (m)
Larson R.	OK 5	May 1, 1987	2.94
		Jun 2, 1987	1.54
		Jun 24, 1987	1.46
		Jul 20, 1987	1.40
		Sep 21, 1987	2.43
		Jan 18, 1988	2.01
		Mar 21, 1988	1.98

Name	Site	Date	Piezometer name (approximate depth)* 5' piez Piezometer length below ground surface (m) 1.71 Water level readings b.g.s. (m)
Davison B.	OK 9	May 14, 1987	0.55
		Jul 20, 1987	0.55
		Sep 21, 1987	0.71
		Nov 9, 1987	0.67
		Mar 21, 1988	0.93

Name	Site	Date	Piezometer name (approximate depth)* 48' piez Piezometer length below ground surface (m) 15.01 Water level readings b.g.s. (m)
M1-84-RH06		May 14, 1987	3.09
		Jun 25, 1987	2.93
		Jul 20, 1987	2.83
		Sep 21, 1987	2.69
		Nov 10, 1987	2.63
		Mar 21, 1988	3.05

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 5' piez	15' piez	30' piez	50' piez	70' piez
			Piezometer length below ground surface (m) 1.38	4.49	8.69	15.06	21.32
			Water level readings b.g.s. (m)				
Larson R.&M.	OK 29	May 22, 1987	-	1.99	dry	14.66	20.77
		Jun 2, 1987	1.37	1.93	7.48	6.28	12.34
		Jun 4, 1987	1.38	1.89	7.08	5.53	11.27
		Jun 8, 1987	1.38	1.90	6.35	4.43	9.45
		Jun 26, 1987	dry	2.03	4.13	2.65	4.89
		Jul 20, 1987	dry	2.00	3.53	3.08	6.00
		Jul 24, 1987	1.36	1.87	3.26	2.78	5.01
		Aug 24, 1987	1.37	1.85	2.27	2.09	2.77
		Oct 29, 1987	dry	2.14	2.07	2.05	2.24
		Nov 9, 1987	1.37	2.16	2.05	2.05	2.08
		Jan 18, 1988	-	2.33	2.36	2.16	2.45
		Mar 16, 1988	dry	2.52	2.51	2.35	2.18
		Mar 21, 1988	dry	2.47	2.48	2.34	2.14

Name	Site	Date	Piezometer name (approximate depth)* 5' piez	18' piez
			Piezometer length below ground surface (m) 1.53	5.80
			Water level readings b.g.s. (m)	
Larson R.&M.	OK 36	Jun 2, 1987	1.49	3.74
		Jun 8, 1987	1.43	3.14
		Jun 26, 1987	1.39	2.09
		Jul 20, 1987	1.13	1.99
		Jul 24, 1987	1.36	1.86
		Nov 9, 1987	dry	1.64
		Jan 18, 1988	dry	2.12
		Mar 16, 1988	dry	2.39
		Mar 21, 1988	dry	2.38

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 5' piez	13' piez
			Piezometer length below ground surface (m) 1.22	4.07
			Water level readings b.g.s. (m)	
Larson R.&M.	OK 37	Jun 2, 1987	1.22	2.21
		Jun 8, 1987	1.22	2.27
		Jun 26, 1987	dry	2.30
		Jul 20, 1987	dry	2.37
		Jul 24, 1987	dry	2.36
		Nov 9, 1987	dry	2.57
		Jan 18, 1988	dry	2.56
		Mar 16, 1988	dry	2.68
		Mar 21, 1988	dry	2.61

Name	Site	Date	Piezometer name (approximate depth)* 8' piez
			Piezometer length below ground surface (m) 2.50
			Water level readings b.g.s. (m)
Larson R.&M.	OK 38	Jun 2, 1987	1.71
		Jun 8, 1987	1.77
		Jun 26, 1987	1.96
		Jul 20, 1987	0.53
		Jul 24, 1987	0.36
		Nov 9, 1987	1.78
		Jan 18, 1988	2.09
		Mar 16, 1988	2.24
		Mar 21, 1988	dry

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 3' piez	8' piez
			Piezometer length below ground surface (m) 1.07	2.42
			Water level readings b.g.s. (m)	
Larson R.&M.	OK 39	Jun 2, 1987	1.07	1.38
		Jun 26, 1987	dry	1.73
		Jul 20, 1987	dry	1.00
		Jul 24, 1987	dry	0.76
		Nov 9, 1987	dry	1.78
		Jan 18, 1988	dry	2.01
		Mar 16, 1988	dry	2.26
		Mar 21, 1988	dry	2.23

Name	Site	Date	Piezometer name (approximate depth)* 8' piez	20' piez	28' piez	73' piez
			Piezometer length below ground surface (m) 2.44	6.22	8.76	18.32
			Water level readings b.g.s. (m)			
Duncan A.	OK 47	Jun 8, 1987	-	-	dry	-
		Jun 9, 1987	-	-	dry	-
		Jun 10, 1987	-	-	7.41	-
		Jun 18, 1987	-	dry	4.34	dry
		Jun 20, 1987	-	5.61	5.03	dry
		Jun 25, 1987	-	3.04	4.12	18.26
		Jul 20, 1987	-	1.43	2.25	15.83
		Jul 21, 1987	-	1.80	2.07	15.65
		Aug 17, 1987	-	1.07	1.56	11.58
		Sep 21, 1987	-	1.21	1.30	8.01
		Sep 29, 1987	-	1.65	1.28	7.36
		Sep 30, 1987	-	1.69	1.27	7.28
		Oct 20, 1987	1.50	1.40	1.52	6.04
		Nov 9, 1987	1.53	1.47	1.33	5.07
		Jan 18, 1988	1.79	1.72	1.43	2.95
		Mar 8, 1988	1.90	1.98	1.70	2.66
		Mar 16, 1988	1.82	1.95	1.73	2.58
		Mar 21, 1988	1.61	1.61	1.94	2.49

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 8' piez	18' piez	28' piez
			Piezometer length below ground surface (m) 2.39	5.72	7.74
			Water level readings b.g.s. (m)		
Tomasiewicz S.	OK 56	Jun 26, 1987	1.37	1.35	1.63
		Jul 20, 1987	1.15	1.12	1.47
		Jul 24, 1987	1.17	1.14	1.43
		Nov 10, 1987	1.45	1.45	1.37
		Mar 21, 1988	2.20	2.12	2.02

Name	Site	Date	Piezometer name (approximate depth)* 18' piez
			Piezometer length below ground surface (m) 5.73
			Water level readings b.g.s. (m)
Martryn G.	OK 58	Jul 20, 1987	0.82
		Jul 21, 1987	0.81
		Nov 10, 1987	1.68
		Mar 21, 1988	2.01

Name	Site	Date	Piezometer name (approximate depth)* 8' piez	13' piez
			Piezometer length below ground surface (m) 2.45	3.96
			Water level readings b.g.s. (m)	
Ivan L.	OK 59	Jul 20, 1987	1.40	1.42
		Nov 10, 1987	2.12	1.98
		Mar 21, 1988	dry	2.51

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 10' piez	43' piez	73' piez
			Piezometer length below ground surface (m) 3.12	12.68	20.69
			Water level readings b.g.s. (m)		
Tomacek W.	OK 61	Jul 20, 1987	1.37	6.80	14.98
		Nov 10, 1987	2.44	2.48	13.19
		Mar 21, 1988	2.67	2.33	14.89

Name	Site	Date	Piezometer name (approximate depth)* 28' piez
			Piezometer length below ground surface (m) 8.09
			Water level readings b.g.s. (m)
Peters E.	OK 62	Jul 20, 1987	1.31
		Sep 21, 1987	1.15
		Nov 11, 1987	1.39
		Mar 21, 1988	1.99

Name	Site	Date	Piezometer name (approximate depth)* 28' piez
			Piezometer length below ground surface (m)
			Water level readings b.g.s. (m)
Gross G.	OK 65A	Jul 15, 1987	(+2.60)
		Aug 28, 1987	(+2.50)
		Sep 21, 1987	(+2.50)
		Mar 21, 1988	Frozen

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 21' piez Piezometer length below ground surface (m) 6.70 Water level readings b.g.s. (m)
Kufner A.	OK 66	Aug 25, 1987	(+1.90)
		Nov 10, 1987	(+2.00)
		Mar 21, 1988	Frozen

Name	Site	Date	Piezometer name (approximate depth)* 6' piez	18' piez	28' piez
			Piezometer length below ground surface (m) 1.62	5.65	8.82
			Water level readings b.g.s. (m)		
Pederson R.	OK 69	Sep 21, 1987	dry	1.58	1.48
		Nov 10, 1987	dry	1.77	1.77
		Mar 21, 1988	dry	2.21	2.23

Name	Site	Date	Piezometer name (approximate depth)* 31' piez Piezometer length below ground surface (m) 9.34 Water level readings b.g.s. (m)
Niska B.	OK 72	Jul 30, 1987	1.05
		Aug 4, 1987	1.11
		Nov 10, 1987	1.73
		Mar 21, 1988	2.19

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 25' piez
			Piezometer length below ground surface (m) 7.48
			Water level readings b.g.s. (m)
Martyn G.	OK 73	Aug 17, 1987	5.56
		Nov 10, 1987	1.12
		Mar 21, 1988	1.18

Name	Site	Date	Piezometer name (approximate depth)* 9' well	31' piez
			Piezometer length below ground surface (m) 2.82	9.53
			Water level readings b.g.s. (m)	
Gifford A.	OK 74	Jul 20, 1987	2.33	-
		Sep 21, 1987	2.38	2.57
		Nov 9, 1987	2.42	1.62
		Mar 21, 1988	-	3.02

Name	Site	Date	Piezometer name (approximate depth)* 28' piez
			Piezometer length below ground surface (m) 8.86
			Water level readings b.g.s. (m)
Derdall B.	OK 76	Aug 26, 1987	1.69
		Nov 9, 1987	1.96

Appendix H. Water level measurements from piezometers

Name	Site	Date	Piezometer name (approximate depth)* 8' piez	38' piez
			Piezometer length below ground surface (m) 1.82	11.37
			Water level readings b.g. (m)	
Kasper J.	OK 77	Sep 21, 1987	dry	4.16
		Sep 29, 1987	dry	3.47
		Nov 9, 1987	dry	2.37
		Mar 21, 1988	dry	2.51

Name	Site	Date	Piezometer name (approximate depth)* 23' piez
			Piezometer length below ground surface (m) 6.87
			Water level readings b.g.s. (m)
Gifford A.	OK 108	Jul 20, 1987	0.90
		Sep 21, 1987	0.89
		Nov 9, 1987	0.87
		Mar 21, 1988	Frozen @ 1.13

Name	Site	Date	Piezometer name (approximate depth)* 271' piez
			Piezometer length below ground surface (m) 82.60
			Water level readings b.g.s. (m)
Stone G.	OK 115	Aug 31, 1987	29.48
		Sep 21, 1987	25.62
		Nov 10, 1987	25.62
		Mar 21, 1988	25.67

* See Appendix G. For exact specifications

APPENDIX I

Chemical analyses of water samples from piezometers

Appendix I. Chemical analyses of water samples from piezometers.

Date Sampled	Testhole No.	Piezometer Name	pH	EC dS/m @25C	Na	Ca+Mg	K	Cl	NO3-N	Na	Ca+Mg	K	Cl	HCO3	Total Cation	Salt*	SAR
					--------mg/L--------					---------meq/L---------					meq/L		
Jun 24, 1987	OK 1	8' P	8.0	19.43	3210	1900	25	454	2	139.6	118.8	0.6	12.8	7.1	259	194	18
		18' P	7.9	18.97	3238	1833	27	499	1	140.8	114.6	0.7	14.1	13.4	256	190	19
		31' P	7.9	19.43	3425	1817	30	516	2	148.9	113.6	0.8	14.5	12.9	263	194	20
		43' P	8.0	13.38	2513	1086	26	420	1	109.3	67.9	0.7	11.8	10.1	178	134	19
Jan 18, 1988	OK 1	8' P	7.6	19.20	2611	2359	34	659	2	113.5	147.4	0.9	18.6	7.5	262	192	13
		18' P	7.7	17.73	2528	2202	38	474	1	109.9	137.6	1.0	13.4	12.2	249	177	13
		31' P	7.4	18.04	2763	2076	42	457	1	120.1	129.8	1.1	12.9	12.9	251	180	15
		43' P	7.8	14.08	2194	1521	37	383	2	95.4	95.1	0.9	10.8	10.1	191	141	14
Jun 24, 1987	OK 2	18' P	8.1	5.38	566	713	11	43	1	24.6	44.6	0.3	1.2	6.3	69	54	5
		38' P	8.1	5.84	768	713	17	61	1	33.4	44.6	0.4	1.7	7.4	78	58	7
Nov 11, 1987	OK 2	18' P	7.9	7.18	553	1121	21	55	1	24.0	70.1	0.5	1.5	6.6	95	72	4
		38' P	8.1	6.64	785	730	26	69	1	34.1	45.6	0.7	1.9	8.0	80	66	7
Jun 24, 1987	OK 5	10' P	7.8	41.80	8304	5037	27	314	2	361.0	314.8	0.7	8.8	13.4	677	418	29
Nov 11, 1987	OK 9	5' P	8.3	1.77	150	213	9	22	2	6.5	13.3	0.2	0.6	6.9	20	18	3
May 14, 1987	M1-84-RH06**	48' P	7.4	5.98	1133	181	8	107	2	49.3	11.3	0.2	3.0	10.8	61	60	21
Jun 25, 1987	M1-84-RH06**	48' P	8.2	6.02	1190	221	14	67	2	51.7	13.8	0.4	1.9	10.7	66	60	20
Nov 11, 1987	M1-84-RH06**	48' P	7.9	6.32	1145	238	15	96	2	49.8	14.9	0.4	2.7	9.1	65	63	18
Jun 26, 1987	OK 29	15' P	8.0	9.11	849	1206	23	182	2	36.9	75.4	0.6	5.1	6.5	113	91	6
		30' P	8.0	5.88	574	690	29	255	1	25.0	43.1	0.7	7.2	11.1	69	59	5
		50' P	8.1	4.21	417	487	23	147	1	18.1	30.4	0.6	4.1	9.1	49	42	5
		70' P	8.3	3.53	531	230	15	92	1	23.1	14.4	0.4	2.6	7.8	38	35	9
Nov 11, 1987	OK 29	15' P	7.8	9.26	798	1426	29	268	1	34.7	89.1	0.7	7.5	7.7	125	93	5
		30' P	7.3	5.93	520	815	34	288	1	22.6	50.9	0.9	8.1	9.8	74	59	4
		50' P	7.5	4.29	368	568	27	168	1	16.0	35.5	0.7	4.7	8.5	52	43	4
		70' P	7.8	3.61	497	273	18	107	1	21.6	17.1	0.5	3.0	6.9	39	36	7
Jan 18, 1988	OK 29	15' P	7.5	9.37	829	1534	28	328	1	36.0	95.9	0.7	9.2	8.0	133	94	5
		30' P	7.3	5.78	522	874	33	311	1	22.7	54.6	0.8	8.8	11.8	78	58	4
		50' P	7.3	4.15	368	614	25	183	1	16.0	38.4	0.6	5.2	10.0	55	42	4
		70' P	7.7	3.45	491	283	17	126	1	21.3	17.7	0.4	3.5	8.5	39	35	7
Jun 26, 1987	OK 36	18' P	8.3	2.94	85	542	9	18	1	3.7	33.9	0.2	0.5	6.0	38	29	1
Jan 18, 1988	OK 36	18' P	7.5	3.16	91	679	13	57	1	4.0	42.4	0.3	1.6	6.2	47	32	1
Jun 26, 1987	OK 37	13' P	8.1	4.74	296	721	20	242	1	12.9	45.1	0.5	6.8	5.1	58	47	3
Nov 11, 1987	OK 37	13' P	7.8	4.96	292	807	27	277	1	12.7	50.4	0.7	7.8	5.9	64	50	3
Jun 26, 1987	OK 38	8' P	7.9	7.75	594	1189	24	65	1	25.8	74.3	0.6	1.8	10.3	101	78	4
Nov 11, 1987	OK 38	8' P	7.8	6.59	429	1071	26	71	1	18.7	66.9	0.7	2.0	10.4	86	66	3

Appendix I. Chemical analyses of water samples from piezometers.

Date Sampled	Testhole No.	Piezometer Name	pH	EC dS/m @25C	Na	Ca+Mg	K	Cl	NO3-N	Na	Ca+Mg	K	Cl	HCO3	Total Cation	Salt*	SAR
					---mg/L---					---meq/L---					meq/L		
Jun 26, 1987	OK 39	8' P	7.8	9.25	624	1507	23	96	1	27.1	94.2	0.6	2.7	9.0	122	93	4
Nov 11, 1987	OK 39	8' P	7.8	9.70	577	1646	33	123	1	25.1	102.9	0.8	3.5	9.8	129	97	3
Jan 18, 1988	OK 47	8' P	8.0	21.38	4816	1306	33	111	5	209.4	81.6	0.8	3.1	15.2	292	214	33
		20' P	7.0	25.76	5896	1841	48	319	2	256.3	115.1	1.2	9.0	14.1	373	258	34
		28' P	6.9	18.04	4046	1024	40	342	1	175.9	64.0	1.0	9.6	12.8	241	180	31
		73' P	7.5	6.66	1327	212	20	314	2	57.7	13.3	0.5	8.8	4.4	71	67	22
Nov 11, 1987	OK 56	8' P	8.0	14.34	2826	774	20	37	1	122.9	48.4	0.5	1.0	9.5	172	143	25
		18' P	8.2	10.94	2018	624	20	31	1	87.7	39.0	0.5	0.9	8.1	127	109	20
		28' P	8.2	8.45	1551	420	19	40	1	67.4	26.3	0.5	1.1	10.7	94	85	19
Nov 11, 1987	OK 58	18' P	8.1	6.43	877	603	27	55	1	38.1	37.7	0.7	1.5	9.7	77	64	9
Nov 11, 1987	OK 59	8' P	8.2	8.86	891	1199	30	49	1	38.7	74.9	0.8	1.4	7.2	114	89	6
		13' P	7.1	6.15	494	936	34	45	1	21.5	58.5	0.9	1.3	1.5	81	62	4
Nov 11, 1987	OK 61	10' P	8.2	30.44	4550	3861	57	410	1	197.8	241.3	1.5	11.5	13.4	441	304	18
		43' P	7.9	12.20	1412	1508	46	267	1	61.4	94.3	1.2	7.5	13.5	157	122	9
		73' P	7.8	10.70	1253	1314	40	182	1	54.5	82.1	1.0	5.1	10.9	138	107	9
Nov 11, 1987	OK 62	28' P	8.0	8.78	1664	451	32	143	1	72.3	28.2	0.8	4.0	12.5	101	88	19
Jul 15, 1987	OK 65A	28' P	7.1	1.61	153	135	12	11	1	6.7	8.4	0.3	0.3	7.8	15	16	3
Sep 21, 1987	OK 65B	33' P	7.6	1.65	136	147	12	9	1	5.9	9.2	0.3	0.3	7.5	15	17	3
Nov 11, 1987	OK 65B	33' P	7.5	1.72	160	192	15	15	1	7.0	12.0	0.4	0.4	6.9	19	17	3
Nov 11, 1987	OK 66	21' P	7.7	4.21	227	720	45	58	1	9.9	45.0	1.2	1.6	7.5	56	42	2
Nov 11, 1987	OK 69	18' P	8.1	4.76	308	758	23	104	1	13.4	47.4	0.6	2.9	6.7	61	48	3
		28' P	8.1	4.18	239	726	26	61	1	10.4	45.4	0.7	1.7	9.0	56	42	2
Nov 11, 1987	OK 72	31' P	7.4	3.60	154	666	28	84	1	6.7	41.6	0.7	2.4	6.2	49	36	1
Nov 11, 1987	OK 73	25' P	8.1	15.00	3004	864	30	358	1	130.6	54.0	0.8	10.1	12.0	185	150	25
Nov 11, 1987	OK 74	31' P	7.7	4.69	735	323	16	159	1	32.0	20.2	0.4	4.5	8.7	53	47	10
Nov/11/87	OK 76	28' P	7.9	1.06	61	170	12	14	1	2.7	10.6	0.3	0.4	5.9	14	11	1
Nov 11, 1987	OK 77	38' P	7.9	19.36	4433	895	23	164	1	192.7	55.9	0.6	4.6	14.3	249	194	36
Jun 26, 1987	OK-108	23' P	7.4	3.79	629	210	14	27	1	27.3	13.1	0.4	0.8	11.0	41	38	11
Nov 11, 1987	OK-108	23' P	7.8	3.83	611	238	14	31	1	26.6	14.9	0.4	0.9	10.1	42	38	10
Aug 31, 1987	OK-115	271' P	7.8	1.69	86	179	15	6	1	3.7	11.2	0.4	0.2	6.6	15	17	2
Sep 21, 1987	OK-115	271' P	7.6	2.06	99	275	14	5	1	4.3	17.2	0.4	0.1	7.2	22	21	1
Nov 11, 1987	OK-115	271' P	7.9	2.12	128	326	12	19	1	5.6	20.4	0.3	0.5	6.8	26	21	2

*Salt = E.C. * 10

** See Christiansen 1984

MAPS
NOT
FILMED

CARTES
OMISES